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THE SEWER SYSTEMS AT RMA HAVE BEEN RECOGNIZED AS MAJOR CONTRIBUTORS TO CONTAMINANT TRANSPORT. COMPLEX COMBINATIONS OF EXFILTRATION AND CONTAMINATED GROUND WATER AND SURFACE WATER INFILTRATION MAY HAVE RESULTED IN THE TRANSPORT OF CONTAMINANTS OVER LARGE AREAS OF THE ARSENAL. MKE HAS INITIATED A FIELD INVESTIGATION OF THE RMA SEWER SYSTEMS IN ORDER TO:

1. UNDERSTAND THE EVOLUTION OF THE SYSTEMS
2. ASSESS THEIR CONDITION
3. MAKE PRELIMINARY DETERMINATIONS OF THEIR ROLE IN CONTAMINANT TRANSPORT.

THIS REPORT SUMMARIZES THE RESULTS OF THE INITIAL PHASE OF WORK. THE PRIMARY PURPOSE OF THIS FIRST PHASE IS TO PROVIDE SUFFICIENT INFORMATION TO SELECT CANDIDATE SITES FOR EXCAVATION, OBSERVATION, AND SAMPLING. THE SCOPE OF WORK INCLUDES:

1. MAP COMPILATION
2. INITIAL FIELD INVESTIGATION

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INTERIM REPORT: PHASE I OF ROCKY MOUNTAIN ARSENAL SEWER INVESTIGATIONS

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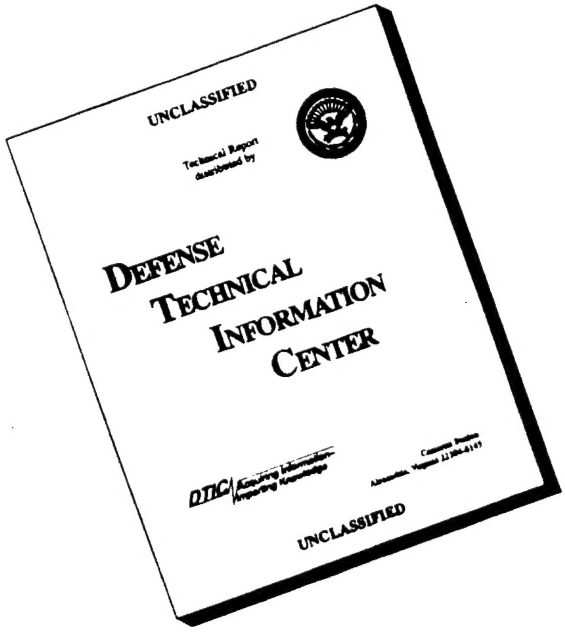

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1.0 INTRODUCTION

Chemical and sanitary sewer systems have been in use at the Rocky Mountain Arsenal since the initial construction of the South Plants and associated facilities in 1942. Some of these systems, such as the main sanitary sewer branches leading to the treatment plant in Section 24, have been only slightly modified since original construction. The chemical sewer system, however, has been extensively modified, rebuilt and partially removed over the course of forty years of operation. Figures 1.1 and 1.2 show the layouts of the sanitary and chemical sewer system over the entire Arsenal.

The sewer systems at Rocky Mountain Arsenal have been recognized by technical investigators as major contributors to contaminant transport. Complex combinations of exfiltration and contaminated groundwater and surface water infiltration may have resulted in the transport of both Army and lessee contaminants over large areas of the Arsenal. Morrison-Knudsen Engineers Inc. has initiated a field investigation of the RMA sewer systems to understand the evolution of the systems, assess their condition and to make preliminary determinations of their role in contaminant transport.

2.0 OBJECTIVE

This interim report summarizes the results of the initial phase of work described in the Morrison-Knudsen Engineers (MKE) document "Chemical and Sanitary Sewer Examination, Technical Plan," August, 1985. The scope of work of this Phase I is described in Section 3.1 of the Technical Plan and is summarized as follows:

- Map compilation and preliminary review.
- Initial field investigation.
  - Field location of manholes and comparison with available mapping.
  - Inspection of manholes.
  - Water level determinations in flooded portions of sewer systems.
  - Sewer water sampling.
  - Air pressure testing of selected portions of sewer systems.
  - Jet cleaning and in-line television inspection of selected portions.

The primary purpose of this first phase of work was to provide sufficient information to select candidate sites for excavation, observation and sampling. The objective of the excavation phase of the field investigation is the determination of the present structural integrity of the sewer systems and their impact on the contamination of soils and groundwater.

3.0 PROCEDURES AND STUDY RESULTS

The methods employed in this first phase of work consist of the following tasks:

- Sewer system layout determination.
- Water level determination in the sewers and adjacent groundwater.
- Water sampling.
- Low pressure air testing.
- Jet cleaning and in-line videotaping.

The following sections summarize the procedures followed and the subsequent results for each of the above tasks.

3.1 SEWER SYSTEM LAYOUT DETERMINATION

3.1.1 Review of Existing Drawings

Research into the available information documenting the original construction and subsequent modifications of and additions to the RMA sewer systems resulted in the following list of drawings summarized in Table 3.1. It is anticipated that other relevant documents will be discovered as work continues with the large volume of available information. The primary sources of drawings were those located in the RMA Facilities Engineering vault and the drawings provided by Shell Chemical Company (Shell).

When available, additional documentation provided by both Shell and the Army production was used to confirm or supplement the information obtained by drawing review.

TABLE 3.1

RMA SEWER SYSTEM DRAWINGS

I. Shell Chemical Company Drawings

ZE 6005-A	June 1960; Utility Layout, Contaminated Waste System, East Plants Area; Shell Chemical Company.
ZE 6005-B	June 1960; Utility Layout, Contaminated Waste Sewer System, West Plants Area; Shell Chemical Company.
ZE 6006-A	June 1960; Utility Layout, Process Water Return System, East Plants Area; Shell Chemical Company.
ZE 6006-B	June 1960; Utility Layout, Process Water Return System, West Plants Area; Shell Chemical Company.
ZE 6003-A	June 1960; Utility Layout, Sanitary Sewer System, East Plants Area; Shell Chemical Company.
ZE 6003-B	June 1960; Utility Layout, Sanitary Sewer System, West Plants Area; Shell Chemical Company.
YE-13347-1	August 1979; Plant Layout, Contaminated Waste Sewer System; Shell Chemical Company.
C-2436	No Date; No Title; Hyman.
YE-12067-4	August 21, 1978; Underground Piping Plan, Denver Effluent Project, Separator and Chemical Hydrolyzer; Shell Chemical Company.
YE-12120-4	August 21, 1978; Underground Piping Plan, Denver Effluent Project, Copper Removal Area; SCC.
YE-12365-2	March 9, 1976; Underground Piping Plan, Project D.E.T., Final Incineration Organic Column & Incineration Area; SCC.
YE-12506-0	August, 1975; Underground Piping Plan, Project D.E.T., Final Incineration Organic Column; SCC.
YE-12600-2	August 20, 1976; Underground Piping Plan, Project D.E.T., Vent Gas Burner Revisions, VGB Bldg. 571 Area; SCC.
YE-13348	April 3, 1978; Contaminated Waste Sewer System, 1st Floor Bldg. 514; SCC.
YE-13352	April 3, 1978; Contaminated Waste Sewer System, Area East of Bldg. 514; SCC.

YE-13353	April 3, 1978; Contaminated Waste Sewer System, Area West of Bldg. 514; SCC.
YE-13354	April 3, 1978; Contaminated Waste Sewer System, Dowtherm Area, Bldg. 514A; SCC.
YE-13335	April 3, 1978; Contaminated Waste Sewer System, Tank Room, 1st Floor Bldg. 514; SCC.
YE-13356	April 3, 1978; Contaminated Waste Sewer System, 1st Floor Bldg. 516; SCC.
YE-13361	April 3, 1978; Contaminated Waste Sewer System, 1st Floor Bldg. 525; SCC.
YE-13365	April 3, 1978; Contaminated Waste Sewer System, Bldg. 512; SCC.
YE-13366	April 3, 1978; Contaminated Waste Sewer System, Area West of Bldg. 512; SCC.
YE-13424	April 3, 1978; Contaminated Waste Sewer System, 1st Floor Bldg. 515; SCC.
YE-13427	April 3, 1978; Contaminated Waste Sewer System, 1st & 2nd Floor, Bldg. 515 Extension; SCC.
YE-13428	April 3, 1978; Contaminated Waste Sewer System, North of Bldg. 515; SCC.
YE-13429	April 3, 1978; Contaminated Waste Sewer System, Bldg. 515A; SCC.
YE-13430	April 3, 1978; Contaminated Waste Sewer System, Bldg. 517; SCC.
YE-13431	April 3, 1978; Contaminated Waste Sewer System, North Room, AB-Unit, Bldg. 422; SCC.
YE-13432	April 3, 1978; Contaminated Waste Sewer System, Tank Room, Bldg. 422; SCC.
YE-13433	April 3, 1978; Contaminated Waste Sewer System, South Room, Bldg. 422; SCC.
YE-13434	April 3, 1978; Contaminated Waste Sewer System, Bldg. 451; SCC.
YE-13435	April 3, 1978; Contaminated Waste Sewer System, 1st Floor, Bldg. 471; SCC.
YE-13438	April 3, 1978; Contaminated Waste Sewer System, Bldg. 532; SCC.
YE-13441	April 3, 1978; Contaminated Waste Sewer System, Area East of Bldg. 511; SCC.
YE-13452-1	May 16, 1978; Foundation Location Plan & Details, Effluent Rail Car Loading Facility; SCC.

II. Army Drawings

18-02-01	Sheet 39 of 71; 1 June 1984; Basic Information Maps, General Sanitary Sewer Map, Area 5; USCOE.
18-02-01	Sheet 40 of 71; 1 June 1984; Basic Information Maps, General Contaminated Waste Map, Area 5; USCOE.

18-02-01	Sheet 38 of 71; 1 June 1984; Basic Information Maps, General Water Map, Area 5; USCOE.
7614-159	April 23, 1943; Chlorine Plant General Utility Map - Industrial & Sanitary Sewer Mains; H. K. Ferguson.
7614-2693	November 7, 1942; T.C. Plant Area - Industrial & Sanitary Sewers; H. K. Ferguson.
7614-2759	August 14, 1943; Storm Drainage & Industrial Waste, Plants Area Except I.O.B.; Whitman, Requardt & Smith - H. A. Kuljian & Co. Engineers (WRS&K).
7614-2762	August 14, 1943; Sanitary Sewers - Plants Area Except I.O.B.; WRS&K.
7614-2013	September 23, 1942; Sewerage Facilities - East Sections Plants Area - Plan & Profile Main B (with revisions); WRS&K.
7164-2014	September 17, 1942; Sewerage Facilities - West Section Plants Area - Plan Main A & Lateral "C" (with revisions); WRS&K.
SK 417	February 26, 1943; Utility Layout Map for Manufacturing Plant Areas - Uncontaminated (Return) System; WRS&K.
SK 418	February 26, 1943; Utility Layout Map for Manufacturing Plant Areas - Contaminated Waste & Surface Drainage; WRS&K.
SK 419	February 26, 1943; Utility Layout Map for Manufacturing Plant Areas - Sanitary Sewer System; WRS&K.
7164-2032	November 9, 1942; Process Waste Disposal; Caustic Waste Basin, Dam & Drainage from Chlorine Plant; WRS&K.
A-8/456.6E/A-1	October 25, 1944; Layout Plan, Steam, Water, Sewer Lines and Sump Pit Details; Office of District Engineer.
D6-3-1	October 25, 1948; Sanitary & Industrial Wastes Revisions and Additions to Main Outfalls for Shell Plant; RMA.
D6-3-2	October 25, 1948; Sanitary Sewer - Plan & Profile M.H.S-A1 to M.H.S-A4; RMA.
D6-2-3	August 4, 1952; Sanitary Facilities - Buildings 751, 752 and Repair Shop; RMA.
E6-5-1	February 19, 1957; Contaminated Waste Line Addition, Plans, Sections and Details, East Plants Area; RMA.
71-07-11	Sheet 1; June 22, 1964; Process Water Lines and Pump Station - Sewer Line Plan and Profile; USCOE.
E2-18-1	March 5, 1976; Contaminated Waste Laterals from MH6 on Chlorine Plant Line to Buildings 313 and 314; RMA.

71-17-01	Sheets 1 to 13; June 14, 1956; Drains and Impervious Blanket (Sewer Plans and Profiles); USCOE.
D-674C	October 1945; West Plants Area Sewerage Facilities; RMA.
D-675C	October 1945; East Plants Area Sewerage Facilities; RMA.
D-676C	September 13, 1954; I.O.B. Area Sewerage Facilities; RMA.
A-8/453.1B/A	January 1944; H Purification and Container Decontaminating Plant; Plot Plan - Pit Drainage, Pump and Steam Lines & Details; Office of District Engineer.
71-08-01	Sheet 1 of 6; May 26, 1952; W.P. Change House, Water and Sanitary Sewer Lines; USCOE.
71-08-01	Sheet 2 of 6; May 26, 1952; Maintenance Change House, Water and Sanitary Sewer Lines; USCOE.
71-08-01	Sheet 4 of 6; May 26, 1952; Warehouses 347, 362 and 363, Water and Sanitary Sewer Lines; USCOE.
A-8/456.158/A-1	December 26, 1944; M74 Program - Cup Filling, Utilities Layout and Details; Office of District Engineer.
A-8/515.1/A-1	May 1, 1945; Additional W.P. Storage Facilities, Plot Plan - Utilities and Details; Office of District Engineer.
71-07-17	Sheet C-2; June 1979; South Plants Liquid Waste Collection System, Civil Site Plan; Black & Veatch, USCOE.
D6-732-1	March 1953; East Plants Area, Contaminated Sewer for Building No. 732; Plan and Profile; RMA.
E6-5-4	January 7, 1977; South Plants Area, Contaminated Waste Sewer System; RMA.
E6-62-1	August 1948; Ton Container Reconditioning Plant, Sewers and Drainage Facilities; RMA.
E6-743-1	July 29, 1975; Building 743, Site Plan and Contaminated Waste Main, Plan and Profile; RMA.
C6-537-1	August 8, 1946; Decontamination Pit Overflow Drain, Trap Detail and Location.
E6-2-4	August 11, 1965; Relocation of Metering Stations on Contaminated Sewer System; RMA.
AW-71-07-09	Sheet 1; February 24, 1961; UDMH-Hydrazine Storage Facility, Disposal Waste Line; Stearns-Roger, USCOE

D6-538-1	June 20, 1946; Ton Container Reconditioning Plant, Building 538, Sewerage and Drainage Facilities; RMA.
D6-60-1	May 7, 1951; HD Shell Filling, Contaminated Sewer Line Plan, RMA.
D6-60-2	May 7, 1952; HD Shell Filling, Profile of Contaminated Sewer Line.
71-07-05	Sheet 1; April 10, 1956; Decontamination and Reconditioning Building, Utilities Plan; Ken R. White A&E, USCOE.
D5-50-13	August 3, 1956; Chlorine Plant Area, Relocation of Stilling Basin, Sump and Pump Plan; RMA.

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3.1.2 Field Confirmation of Sewer Alignment

A review of the available documentation of the RMA sewer systems resulted in apparent discrepancies between various sources. Examples of such discrepancies are: pipe diameters, manhole locations, horizontal alignment and contradictory building service line locations. Therefore, field reconnaissance surveys commenced in October 1985 by Morrison-Knudsen Engineers to both confirm the accuracy of the drawings and resolve, when possible, the discrepancies. The South Plants sanitary sewer system, the sanitary main lines to the treatment plant in Section 24, the South Plants contaminated sewer system and the portion of the North Plant contaminated sewer in Section 36 were traced on foot and inspected from the surface without lifting manhole covers. This allowed the investigating team to quickly determine the areas of questionable alignment and to check the drawings against field conditions.

A review of the June, 1960 Shell Chemical Company drawings, ZE 6003-(A&B), ZE 6005-(A&B) and ZE 6006-(A&B), indicated that a color coding system existed for manholes. Sanitary sewer manholes were yellow, contaminated waste sewer manholes red and process water return manholes blue. Field observation indicated that many manholes had residual paint from this earlier color coding. It was often necessary to locate manholes under asphalt paving, gravel, or soil using a magnetic locator, and then uncover them with hand tools. In several instances, manholes could not be located using these techniques. When the available documentation confirmed the use of a particular manhole that showed no signs of past painting, MKE personnel spray painted the cover the appropriate color.

Prior to MKE field reconnaissance, representatives of Ebasco Services Incorporated, an Army contractor, had conducted a similar exercise. In those instances where a manhole could not definitely be determined to be part of either the sanitary, contaminated, or process water return system, the Army

contractor painted it both blue and red. After consultation with the RMA Facility Engineer and Ebasco, the MKE team repainted some of these manholes the appropriate color after a careful review of the available drawings. Even after this effort, however, several manholes could not be categorized due to a lack of documentation.

To provide information for future health and safety determinations, the MKE field reconnaissance team inserted instrumentation probes into any manholes which provided access without lifting the covers. Readings were taken with a Combustible Gas Meter, Organic Vapor Analyzer, and an Army M8 Surety Agent Meter. No positive indications of Army agents were detected, although organic vapors were detected in both the sanitary and contaminated waste sewers.

After the initial field reconnaissance of sewer manholes was conducted, MKE personnel returned to those areas of the sewer systems where identification was not possible from surface observation only and removed the manhole covers for subsurface observation. This procedure was conducted in "Level B" protective clothing and equipment (supplied air respiratory protection). Readings were taken with the health and safety instrumentation, and field notes were compiled indicating the orientation and approximate diameter of incoming and exiting sewer pipes and the construction materials of manholes and pipes. No manholes were entered - all observations were made from the ground surface. Some manholes were observed to be flooded with water and/or filled with soil or concrete and therefore observation of pipe alignment was not possible. Comparison with the available drawings confirmed that field conditions were often not accurately depicted by any of the documents assembled in the original research effort. Typical examples of such discrepancies include dozens of unmapped pipes entering manholes from unknown sources, contradictory pipe alignments and different pipe materials. Such conditions were particularly evident in the contaminated sewer system.

In addition to the drawings listed in Table 3.1, a 1979 Shell Chemical Company compilation of contaminated sewer manhole data was utilized in the field reconnaissance effort. (Appendix A). Although this document did not address several of the contaminated sewer manholes, it proved helpful in furthering MKE understanding of the flooded portions of the system.

Health and safety instrumentation readings taken in manholes which had no openings to the atmosphere and therefore no opportunity to vent light organics often showed high levels of organic vapor concentrations. For example, contaminated manhole W1 (Shell Chemical Company designation) was uncovered in the middle of a gravel road under three inches of hard packed soil and gravel (Figure 3.3). The Organic Vapor Analyzer (OVA) ionization detector flame was extinguished after "pegging" at the maximum scale reading of 1000 ppm. The Lower Explosive Limit reading in the manhole was twenty-four percent. Table 3.2 summarizes all organic vapor concentration readings taken in the RMA manholes. The table reflects the increases in organic vapor concentrations due to the jet cleaning of the sewers during the television inspection work described in Section 3.6 of this report.

3.2 DESCRIPTION OF SOUTH PLANTS SEWER SYSTEMS

Figures 3.1, 3.2 and 3.3 show the current understanding by MKE of the South Plants contaminated and sanitary sewer systems. These drawings depict the underground sewers prior to the installation of the Shell Chemical Company above-ground contaminated sewer in 1980-1981. Figure 3.3, showing the contaminated sewer system on the east side of the South Plants, includes the Army Liquid Waste Collection System which at present collects chemical waste from active Army buildings, stores the liquid in Tank 555 and then treats the liquid prior to discharge to the sanitary sewer system.

TABLE 3.2

HEALTH AND SAFETY INSTRUMENTATION READINGS FROM RMA SEWER MANHOLES (OCTOBER-DECEMBER, 1985)

MANHOLE NUMBER	OVA READINGS[1], ppm	MANHOLE NUMBER	OVA READINGS[1], ppm
Contaminated Sewer:			
E1	3.4, 1.5	W3	9.4
E2	24.0, 1.0	W4	1.2, 1.0
E3	100, 1.4	W4A	2.0, 1.0
E4	1.8, 1.0	W5	1.0, 1.1
E4A	24.0	W6	1.6, 1.1
E4B	10.0, 1.2	W6A	2.0, 1.0
E5	9.0	W6B	4.1, 1.2
E5A	4.6, 4.0	W6C	3.0, 1.0
E5B	1.4, 1.1	W7	3.0
E6	3.6	W9	>1000
E7	10.0, 1.0	W11	150, 1.0
E7A	6.0	W12	5.0, 1.0
E7B	9.0	W15	1.0
E7C	2.5	W16	12.0, 1.0
E7D	50.0, 35.0	W17	5.0, 1.0
E8	5.2	W18	1.1, 1.0
E11	>1000	W21	32.0, 1.0
E11A	300	W22	5.4, 1.4
E11B	400	W22A	2.6, 2.4
E12	1.0	W22B	2.0
E13	1.0	W23	1.8
E15	1.0	W24	1.0
E16	1.0	W25	5.0, 1.0
EW1	1.0	W26	30.0, 1.4
W1	>1000, 7.0	W27	8.0, 1.4
W1A	5.0, 1.0	W28	200.0, 1.8
SW of W2	22.0, 7.0	W29	4.0, 1.0
		W30	1.4
Army Numbering:			
4	1.0	5-2	1.0
1-A	80.0, 1.1	5-3	1.0
A	1.0	5-4	1.0
B	1.4-1.0		

MANHOLE NUMBER	OVA READINGS[1], ppm	MANHOLE NUMBER	OVA READINGS[1], ppm
Sanitary Sewer:			
Army Numbering:			
S3	1.0	100	30.0, 2.2
S4	1.0	105	3.0, 2.0
S5	1.1, 1.0	106	14.0
S6	4.2, 1.0	107	2.5
S9	1.0	SA1	12.0, 16.0
40	2.1, 1.0	113	3.0, 1.0
41	1.0	117A	3.0
42	1.0	117B	20.0, 1.7
46	1.8, 1.1	119B	27.0, 1.0
62	1.1	120 (new)	2.0
89	2.6, 1.0	120A	1.0
	PHOTOVAC TIP, ppm		**PHOTOVAC TIP, ppm**
84	4.4	89	3.5
85	2.7	95	18.5
87	3.5	97	45.0
88	2.0		

[1]Organic Vapor Analyzer - Instrument zeroed at 1.0 ppm, maximum and minimum values reported

The following discussion briefly summarizes the evolution and operation of the various systems.

3.2.1 West Side Sanitary Sewer (Figure 3.1)

The South Plants sanitary sewer system west of D Street was, for the most part, constructed before any lessees entered RMA. The sewer is primarily a vitrified clay pipe gravity sewer with lift stations located by Buildings 364 and 341A (Figure 3.1). The original construction around the Chlorine Plant area (Buildings 241, 242, 251, 254, etc.) and the Power Plant area (Buildings 321, 325) is intact, and, other than a few additional service lines, has not been extensively modified. The majority of the sanitary sewers serving the southwest warehouse area (south of manhole 110A) were constructed in 1944 or 1945 (per Army Drawing A-8/456.6E/A-1). The lines serving Buildings 347, 362 and 363 (west of manhole 111I and south of manhole 111H) were constructed in 1953 or 1954, based on a review of Army Drawing 71-08-01, Sheet 4 of 6. The 1984 RMA Master Plan Maps (18-02-01, Sheet 39 of 79) indicate an additional line terminating at the east end of Building 362, but this was not located in the field.

The Chlorine Plant area is inactive; no flows were observed in the sanitary sewer west of manhole 105. The Power Plant and some warehouses are still in service, however, and sewage flows were observed entering manhole 107 on D Street.

3.2.2 East Side Sanitary Sewer (Figure 3.2)

The South Plants sanitary sewer system east of D Street has seen more modifications over its lifetime than the west side (Figure 3.2). The mains serving the mustard manufacturing area (manholes 122 to 101) and the incendiary oil bomb plant (manholes 124 to 126) are part of the original Arsenal construction in 1942. The line connecting manholes 115B

(originally 115) to 101 was abandoned in late 1943 with the construction of the third M-1 Settling Basin, and the system was re-routed east to a new 115 and north to manhole 100 (Army Drawing 7164-2013, Revision IV).

In 1945, the line from manhole 116 to 117 was installed (Army Drawing A-8/456.15B/A-1) along with the lateral from manhole 125 to 125C (Army Drawing A-M-1). In 1948, the main from manhole SA-1 to SA-4 was constructed (Army Drawing D6-3-2). In 1952 to 1953 this line was extended to serve Buildings 543B, 544, 751 and 752 by installing a lift station and manholes SA-4A, SA-5 and SA-6 (Army Drawing D6-2-3). Also in 1952, the line from 117 serving Building 522B was installed (Army Drawing 71-08-01, Sheet 1 of 6). In 1974, manholes 120A through 120E were installed and the sanitary sewer south of manhole 120 was abandoned.

3.2.3 West Side Contaminated Sewer (Figure 3.1)

The South Plants contaminated sewer west of D Street originally served as both a conveyance for chemical waste and a storm sewer (Figure 3.1). The original 1942 system consisted of a vitrified clay pipe network in the Chlorine Plant area that collected contaminated waste and surface runoff and routed it south through pipes and open ditches that eventually flowed west to Sand Creek Lateral. The original manholes (designated by the "I" numbering series) were often covered with open grates that allowed surface runoff entry to the system. MKE field personnel have located these manholes and observed the grated manhole covers. In addition to serving the Chlorine Plant, the sewer received wastes associated with the phosgene bomb filling activities in Building 331 in 1944 (Army Drawing D-674C).

In 1956, with the construction of Basin F, the Army constructed a contaminated sewer to transport South Plant wastes to Basin F. Manholes 4-1, 4-2 and 4-3 were built in the Chlorine Plant area

at this time to re-route the Chlorine Plant wastes north to the original caustic waste line (manhole 6) and on to Basin F. This new line picked up effluent from the original Chlorine Plant contaminated sewer by the operation of a cross-connection and pump (See detail, Figure 3.1).

In 1976, the Army ran a lateral from Buildings 313 and 314 west across D Street and joined the sewer to Basin F at manhole 6 (manholes 6-1, 6-2, 6-3 and 6-4). This is depicted by Army Drawing E2-18-4.

3.2.4 East Side Contaminated Sewer (Figure 3.3)

The east side of the South Plants contaminated sewer system has seen the most extensive and complex series of modifications of any of the RMA sewer systems. Figure 3.3 depicts the underground system as it existed prior to the 1980-1981 construction of the Shell above-ground system. This system became completely operational in January of 1982.

The original contaminated sewer system in the east side of the South Plants was a conveyance for chemical effluents and storm runoff. The system consisted of a network of gravity vitrified clay pipes, open, unlined ditches and culverts that terminated at the 30-inch pipe just west of the M-1 Settling Basins. The M-1 Basins received process wastes from early Army Lewisite production in Building 514 via a system of above-ground pressure piping. The waste was neutralized with lime slurry from acetylene production, the solids settled out and the liquid decanted to the 30-inch main. The 30-inch main then crossed under December 7th Avenue, turned northeast at manhole 1-A and discharged to the Lime Settling Basins. Manhole 1-A has been located by MKE field personnel. The manhole is flooded with water due to the plugging of the outfall pipe with brick and mortar.

The main contaminated gravity sewer line that received wastes from the original Army production during the war years is shown on Figure 3.3 as manholes W12, W15, W16, W21, W22, W25, W26, W27, W28, W29, (14), (15), (16), (17), and W31. (The numbers in parentheses designate Army numbering; the "W" and "E" series manholes designate Shell numbering.) Although certain portions of this line may have been replaced, an MKE review of the available documentation has concluded that this reach is essentially the same today as it was in 1942. Exceptions to this would be rebuilt or replaced manholes and the bypass of manhole (12) with the construction of W28 (See Army Drawing 7614-2759).

Underground gravity sewer service to Army buildings 514, 536, 537 and 538 was originally provided around 1944 to 1946 with the construction of manholes (1), (1A), (1B), (1C) and (2) (Army Drawings D6-538-1, C6-537-1 and A-8/453.1B/A-1). This construction received waste from mustard purification and ton container decontamination activities and transported it directly north across December 7th Avenue and past the east edge of the Lime Settling Basins to Basin A. At approximately the same time in this same area, manholes (4), (5), (6), (6A), (6B) and (1D) were constructed and discharged to the same 12-inch vitrified clay pipe that crossed December 7th Avenue (Army Drawings E6-62-1 and C6-537-1).

In 1951, a force main was constructed connnecting 742A to manhole (1A) north of Building 538 (Army Drawing D6-60-1). This main discharged to an unnumbered trap, or manhole, immediately south of Building 727. From this structure it flowed by gravity to manhole (1A) and on to Basin A.

In 1953, a contaminated sewer receiving effluent from Building 732 was constructed. This line crossed December 7th Avenue and discharged to a ditch in Section 36 that routed the effluent to Basin A (Army Drawing D6-732-1). The ditch is

visible in available aerial photography and, along with the associated manholes, has been located in the field by MKE personnel.

Also in 1953, the Julius Hyman Company installed a 12-inch sewer that tied into the existing line between manholes (1B) and (1). Manholes H-1 and H-2 were constructed at this time (Julius Hyman Drawing C-2436). This line provided a means of segregating Hyman waste flows from Army waste, and discharged them to a stilling basin located at the southeast corner of the Lime Settling Basins. The effluent entered Basin A from the stilling basin via an open ditch. At some time between 1960 and 1976, the line between manholes E5 (originally H-1) and E11 was abandoned and bypassed with the construction of E2, E3 and E4 (Shell Drawing ZE-6005-A, Revised 1976).

The construction of these parallel sewer lines made it possible to install the "east meter" (adjacent to Building 503 in Figure 3.3) in 1965, thereby allowing the monitoring of Shell effluents separately from the Army's (Army Drawing E6-2-4). Prior to this meter installation the flows were simply recombined north of December 7th Avenue and routed to Basin F with its construction in 1956.

In 1957, the Army constructed a 6-inch sewer line and manholes (21), (22) and (23) to carry waste flows from Buildings 313 and 314 (the lab and laundry) to the main sewer at manhole W21 (4) (Army Drawing E6-5-1). Until this time, the flows from these two buildings were carried by culverts and open, unlined ditches to the original 30-inch main running northward along the western edge of the M-1 Settling Basins. With the construction of the west meter in 1965 (Army Drawing E6-2-4), the Army flows from the lab and laundry were included in the metered volumes. This was remedied by the 1976 construction of a branch sewer which carried the lab and laundry waste flows west across "D" Street to manhole 6 in the Chlorine Plant area (Army Drawing E2-18-4).

The main sewers in the area of Building 534B, the Shell-built Planavin unit, were built in 1965. It is known from the Shell documents that manhole W3 was constructed in 1970 when the line between W2 and W4 was abandoned. Later, in 1977, the line between W3 and W4 was abandoned.

In 1975, the Army constructed a force main from Building 743 to the then existing manhole south of Building 727 (Army Drawing E6-743-1). Later, in 1979, this segment was incorporated into the South Plants Liquid Waste Collection System, which collects Army effluents, stores them in a 170,000 gallon tank ("Building" 556) and routes them to a treatment unit in Building 540 prior to discharge to the sanitary sewer (Army Drawing 71-07-17, Sheets C-2). Force mains "A", "B", "C", and "D" are part of this 1979 collection system and are still operational today.

One portion of the South Plants contaminated sewer system that has seen particularly extensive modifications is the area served by manholes W31, W32 and W33. As shown on Figure 3.3, manhole W33 is precast concrete, and manhole W32 has been converted to a sump that discharges to the sewer north of Building 451. A review of Shell documentation indicates that these changes were made in 1979, and resulted in the abandoning of the contaminated sewer upstream of W27.

Prior to the installation and partial operation of the Shell above-ground sewer system (1980 to 1981), the Denver Effluent Treatment (DET) system received effluents from the underground gravity sewer by pumps located in Buildings 503 and 502 near the east and west meter pits. The pumps and sumps associated with Buildings 503 and 502 were installed in 1975. Later, in 1978, Shell disconnected from the main sewer that transported contaminated waste to Basin F. Also at this time, the 12-inch line connecting manholes W1 to E2, along with manhole EW1, was installed to allow the transfer of effluent from the west side

to the east. Presumably, the portions of the contaminated sewer near the DET system (buildings north and east of 538) were constructed prior to disconnecting from the sewers to Basin F in 1978.

3.3 WATER LEVEL DETERMINATIONS

The field reconnaissance survey of the South Plants contaminated sewer system indicated that a significant portion of the system was flooded with water. Therefore, the MKE investigation team took measurements of the water levels in the manholes to determine the relationship of the sewer water to the South Plants groundwater table. Figure 3.4 depicts the flooded portions of the contaminated sewer.

3.3.1 Contaminated Sewer Water Levels

As shown by Figure 3.4, the portion of the South Plants contaminated sewer along December 7th Avenue is flooded. In 1982, the Army plugged the three northbound contaminated sewer mains exiting the South Plants. The 12,000 feet of contaminated sewer from immediately north of December 7th Avenue to Basin F in Section 26 was removed at this time. Field observations by MKE personnel in October 1985 indicated that many surface water entry points into the contaminated sewer still exist in the South Plants area. Uncovered sumps and area drains apparently allow precipitation and runoff to recharge the system. Presumably, any leaking roofs in abandoned process buildings would also contribute to this recharge via floor drains.

From mid-October to early November 1985 and also in April of 1986, MKE personnel took measurements of water depths in the South Plants contaminated sewer manholes to determine water surface elevations in the system. Differential level circuits were run from the southwest corner of Section 36 into the South Plants area to verify the relative elevations of manhole rings

as reported by Shell Chemical Company documentation (Appendix A). This MKE vertical control survey was based on the National Geodetic Survey (NGS) datum established on the RMA by International Technology Limited (ITECH) in March, 1985 to support Environmental Science and Engineering, Inc. work in Section 36. This surveying confirmed the approximate relative elevations of manhole rings as shown in Appendix A (± 0.3 feet) and also indicated that the Shell data in Appendix A was based on a datum approximately 0.6 feet higher than the NGS datum. (Comparison of ITECH's elevations for Section 36 corners with RMA Facility Engineer drawings showed on average a one foot differential.)

Measurements were made of the water surface levels below the manhole rings in the flooded South Plants contaminated sewer manholes. This data, along with the information in Appendix A, was used to construct profiles of the flooded portions of the contaminated sewer as shown in Figures 3.5A and 3.5B. Horizontal distances between manholes were estimated by scaling the lengths from Shell Chemical Company drawing YE-13347-1, August 1979.

3.3.2 Groundwater Levels

The profiles of the flooded portions of the South Plants contaminated sewers (Figures 3.5A and 3.5B) depict the groundwater table based on measurements taken in eighty-nine Shell Chemical Company wells during May and September of 1985. This well data was used to produce a computer-generated water table map and to prepare Figure 3.4, thereby assisting the MKE investigation team in selecting candidate sewer excavation sites that would not produce large volumes of water.

Inspection of the sewer profiles in Figure 3.5A and 3.5B shows that the water elevations in the northern-most manholes along December 7th Avenue (E1 and W1) were over four feet higher than

the adjacent groundwater table during October, 1985. Presumably, wet weather directly recharges the sewers by means of exposed sumps and area drains, and water levels quickly rise in the downstream manholes. Afterwards, the system would equilibrate by exfiltrating into the groundwater. Insufficient information is available at this time to arrive at conclusions on exfiltration and infiltration rates and their distribution along the pipeline.

3.4 SEWER WATER SAMPLING

MKE personnel sampled the standing water in the South Plant contaminated sewers and also in the sanitary sewer system both in the South Plants and north of December 7th Avenue in November and December of 1985 and early January 1986. One objective of this sampling program was to characterize the water likely to be encountered in the sewer excavation phase and determine if it constitutes a hazardous rating under RCRA. A second objective was to provide sufficient water quality data to support a water treatment contingency plan in the event that the sewer excavation program generated significant volumes of water requiring treatment. Analysis was provided by the Rocky Mountain Analytical Laboratory, and analytical results are summarized in Table 3.3.

The sewer water sampling program sampled twenty-four manholes that were incorporated into ten individual samples and five composite samples, each composite representing two or more consecutive manholes of a particular portion of the sewer system. Refer to Figures 3.6, 3.7 and 3.8 to locate the areas of the sanitary and contaminated sewer systems that were sampled.

The samples collected in the abandoned contaminated sewers were taken from the relatively static water standing in the manholes. The assumption was made that vertical stratification would

TABLE 3.3

SEWER WATER ANALYSIS

INORGANIC PARAMETERS	UNITS	MANHOLE DATE MCL	E 1 10/18/85	E2-E7 11/6/85	E4B-E5A-E5B 11/14/85	4 11/6/85	W 1A 10/18/85
CORROSIVITY	pH	<2 to >12	7.75	7.86	8.09	7.55	7.21
IGNITABILITY	F	<140	105#	115#	95#	119#	117#
REACTIVE SULFIDE	mg/l	NOT DEF.	ND(0.05)	ND (0.5)	ND(0.5)	ND(0.5)	ND (0.05)
REACTIVE CYANIDE	mg/l	NOT DEF.	ND (0.1)	ND (0.1)	ND (0.01)	ND (0.1)	ND (0.1)
TOTAL DISSOLVED SOLIDS	mg/l	---	---	440 (10)	410 (10)	220 (10)	---
TOTAL SOLIDS	mg/l	---		510 (10)	480 (10)	490 (10)	---
TOTAL VOLATILE SOLIDS	mg/l	---	---	100 (10)	90 (10)	90(10)	---
TOTAL ORGANIC CARBON	mg/l	---	---	11 (0.1)	9.9 (0.1)	12 (0.1)	---
RCRA EP TOXICITY METALS	UNITS	MCL					
ARSENIC	mg/l	5.0	ND (0.5)	0.004(0.002)	ND (0.02)	0.006(0.002)	ND (0.5)
BARIUM	mg/l	100.0	ND (0.05)	0.034(0.005)	0.042 (0.005)	0.042(0.005)	0.06 (0.05)
CADMIUM	mg/l	1.0	ND (0.04)	0.071(0.004)	0.035 (0.004)	0.011(0.004)	ND (0.04)
CHROMIUM	mg/l	5.0	ND (0.05)	ND (0.005)	ND (0.005)	ND (0.005)	0.05 (0.05)
LEAD	mg/l	5.0	ND (0.25)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.25)
MERCURY	mg/l	0.2	ND (0.001)	0.007(0.001)	0.001 (0.001)	ND (0.001)	ND (0.001)
SELENIUM	mg/l	1.0	ND (0.02)	ND (0.002)	ND (0.02)	ND (0.002)	ND (0.02)
SILVER	mg/l	5.0	0.058 (0.03)	ND (0.003)	ND (0.003)	ND (0.003)	0.094(0.03)
RCRA EP TOXICITY ORGANICS, PESTICIDES		MCL					
LINDANE	ug/l	400	ND(1.3)	ND (0.08)	ND (0.02)	ND (0.2)	ND (0.29)
4,4,'-DDT	ug/L	---	ND (7.8)	ND (0.24)	ND (0.06)	ND (0.6)	ND (0.6)
ENDRIN	ug/L	20	ND (0.39)	ND (0.12)	ND (0.3)	ND (0.3)	ND (0.43)
METHOXYCHLOR	ug/L	10,000	ND (16)	ND (5.0)	ND (1.25)	ND (12.5)	ND (18)
TOXAPHENE	ug/L	500	ND (16)	ND (4.8)	ND (1.20)	ND (12.0)	ND (17)
PRIORITY POLLUTANT ORGANICS	UNITS	MCL					
B-BHC	ug/L	---	---	---	ND (0.015)	ND (0.15)	---
ALDRIN	ug/L	---	---	---	0.27 (0.020)	3.4 (0.20)	---
DIELDRIN	ug/L	---	---	---	ND (0.010)	5.6 (0.1)	---
ENDRIN KETONE	ug/L	---	---	---	ND (0.010)	7.9 (1.0)	---
ENDRIN ALDEHYDE	ug/L	---	---	---	0.28 (0.12)	ND (1.2)	---

NOTES AND ABBREVIATIONS

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SEWER WATER ANALYSIS - Page 1

SEWER WATER ANALYSIS

		MANHOLE	W1-PIT	W4-W6	W7-W15	W 88	S A1
		DATE	11/7/85	11/14/85	11/7/85	10/18/85	1/15/86
INORGANIC PARAMETERS	UNITS	MCL					
CORROSIVITY	pH	(2 to)12	8.58	7.36	7.33	7.09	7.43
IGNITABILITY	F	(140	118*	122*	101*	119*	89*
REACTIVE SULFIDE	mg/l	NOT DEF.	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.05)	ND (1.0)
REACTIVE CYANIDE	mg/l	NOT DEF.	ND (0.1)	ND (0.01)	ND (0.1)	ND (0.1)	ND (0.01)
TOTAL DISSOLVED SOLIDS	mg/l	---	450 (10)	370 (10)	240 (10)	---	505 (10)
TOTAL SOLIDS	mg/l	---	1600 (10)	500 (10)	290 (10)	---	530 (10)
TOTAL VOLATILE SOLIDS	mg/l	---	150 (10)	65 (10)	60 (10)	---	ND (10)
TOTAL ORGANIC CARBON	mg/l	---	29 (0.1)	16 (0.1)	15 (0.1)	---	36 (0.1)
RCRA EP TOXICITY METALS	UNITS	MCL					
ARSENIC	mg/l	5.0	0.28 (0.002)	ND (0.02)	2.0 (0.4)	ND (0.05)	0.06 (0.002)
BARIUM	mg/l	100.0	0.060 (0.005)	0.051 (0.005)	0.039(0.005)	0.22(0.005)	0.04 (0.005)
CADMIUM	mg/l	1.0	ND (0.004)	ND (0.004)	0.021(0.004)	0.054(0.004)	ND (0.004)
CHROMIUM	mg/l	5.0	ND (0.005)	ND (0.005)	ND (0.005)	0.27(0.005)	ND (0.005)
LEAD	mg/l	5.0	ND (0.025)	ND (0.025)	ND (0.025)	0.18(0.025)	ND (0.025)
MERCURY	mg/l	0.2	ND (0.001)	0.001 (0.001)	ND (0.001)	ND (0.001)	ND (0.001)
SELENIUM	mg/l	1.0	ND (0.002)	ND (0.02)	ND (0.002)	ND (0.02)	ND (0.002)
SILVER	mg/l	5.0	ND (0.003)	ND (0.003)	ND (0.003)	0.15 (0.003)	ND (0.003)
RCRA EP TOXICITY ORGANICS, PESTICIDES		MCL					
LINDANE	ug/l	400	ND (20)	ND (0.2)	ND (2.0)	ND (2.2)	ND (0.09)
4,4,'-DDT	ug/L	---	ND (60)	ND (0.6)	ND (6.0)	ND (66)	ND (0.24)
ENDRIN	ug/L	20	ND (30)	ND (0.3)	ND (3.0)	ND (3.3)	ND (0.12)
METHOXYCHLOR	ug/L	10,000	ND (1250)	ND (12.5)	ND (125)	ND (140)	ND (5.0)
TOXAPHENE	ug/L	500	ND (1200)	ND (12.0)	ND (120)	ND (130)	ND (4.8)
PRIORITY POLLUTANT ORGANICS	UNITS	MCL					
a-BHC	ug/L	---	---	---	ND (0.15)	3.2 (1.5)	---	---
ALDRIN	ug/L	---	---	---	ND (0.20)	ND (2.0)	---	---
DIELDRIN	ug/L	---	---	---	1.4 (0.1)	9.2 (1.0)	---	---
ENDRIN KETONE	ug/L	---	---	---	ND (1.0)	7.1 (10)	---	---
ENDRIN ALDEHYDE	ug/L	---	---	---	ND (1.2)	ND (12.0)	---	---

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SEWER WATER ANALYSIS - Page 1.1

SEWER WATER ANALYSIS

INORGANIC PARAMETERS	UNITS	MANHOLE / DATE / MCL	S 40 1/14/86	S 46 1/14/86	S 62 1/14/86	S 89 1/14/86	S 100 1/14/86
CORROSIVITY	pH	<2 to >12	7.07	7.03	7.49	7.15	6.79
IGNITABILITY	F	<140	117*	105*	115*	NF	NF
REACTIVE SULFIDE	mg/l	NOT DEF.	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
REACTIVE CYANIDE	mg/l	NOT DEF.	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
TOTAL DISSOLVED SOLIDS	mg/l	---	260 (10)	220 (10)	300 (10)	290 (10)	280 (10)
TOTAL SOLIDS	mg/l	---	280 (10)	260 (10)	300 (10)	320 (10)	280 (10)
TOTAL VOLATILE SOLIDS	mg/l	---	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
TOTAL ORGANIC CARBON	mg/l	---	25 (0.1)	58 (0.1)	19 (0.1)	32 (0.1)	34 (0.1)
RCRA EP TOXICITY METALS	**UNITS**	**MCL**					
ARSENIC	mg/l	5.0	0.018 (0.002)	0.016 (0.002)	ND (0.002)	0.012 (0.002)	0.032 (0.002)
BARIUM	mg/l	100.0	0.019 (0.005)	0.020 (0.005)	0.009 (0.005)	0.023 (0.005)	0.035 (0.005)
CADMIUM	mg/l	1.0	ND (0.004)	ND (0.004)	ND (0.004)	ND (0.004)	ND (0.004)
CHROMIUM	mg/l	5.0	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
LEAD	mg/l	5.0	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)
MERCURY	mg/l	0.2	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)
SELENIUM	mg/l	1.0	ND (0.002)	ND (0.002)	ND (0.002)	ND (0.002)	ND (0.002)
SILVER	mg/l	5.0	ND (0.003)	ND (0.003)	ND (0.003)	ND (0.003)	ND (0.003)
RCRA EP TOXICITY ORGANICS, PESTICIDES		**MCL**					
LINDANE	ug/l	400	ND (0.09)	ND (0.09)	ND (0.09)	ND (0.09)	ND (0.09)
4,4,'-DDT	ug/L	---	ND (0.24)	ND (0.24)	ND (0.24)	ND (0.24)	ND (0.24)
ENDRIN	ug/L	20	ND (0.12)	ND (0.12)	ND (0.12)	ND (0.12)	ND (0.12)
METHOXYCHLOR	ug/L	10,000	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
TOXAPHENE	ug/L	500	ND (4.8)	ND (4.8)	ND (4.8)	ND (4.8)	ND (4.8)
PRIORITY POLLUTANT ORGANICS	**UNITS**	**MCL**					
B-BHC	ug/L	---	---	---	---	---	---
ALDRIN	ug/L	---	5.3 (-)	5.6 (-)	---	3.2 (-)	---
DIELDRIN	ug/L	---	---	---	---	---	---
ENDRIN KETONE	ug/L	---	---	---	---	---	---
ENDRIN ALDEHYDE	ug/L	---	---	---	---	---	---

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(-)=NOT REPORTED

require a depth-integrated sample. The sampling depth interval was one foot. Sanitary sewer samples were taken in the flowing stream of water in the operating sewers.

Sampling methodologies in this effort were based on the techniques outlined in the USEPA manual Characterization of Hazardous Waste Sites - A Methods Manual: Volume II, Available Sampling Methods (EPA-600/4-83-040). All samples were routed through the RMA laboratory (Building 313) for surety clearance. Proper Chain of Custody procedures were followed and Quality Control samples (field blanks, field spikes, known concentration samples, sample replicates) were incorporated into the analytical program.

3.5 LOW PRESSURE AIR TESTING

In November and December of 1985, MKE conducted low pressure air testing of selected portions of the RMA sanitary and contaminated sewer system. This work was accomplished by subcontract to Guildner Pipeline Maintenance, Inc., a firm in the Denver area with past experience at Rocky Mountain Arsenal. The procedures described in ASTM C 828-80, "Low-Pressure Air Test of Vitrified Clay Pipelines" was followed. This specification is in Appendix B of this report.

The objective of this testing was to assist the investigators in refining the selection of specific sewer excavation sites. Low pressure air testing is an accepted technique for demonstrating the relative structural integrity of newly installed vitrified clay pipelines. It was recognized that due to the age of the original RMA sewers (forty plus years) and the severe service conditions, the test could only be an indicator of sewer segments that may warrant further investigation. The test is not considered in itself an adequate indicator of the structural integrity of a sewer.

The segments of the RMA sewer systems that were air pressure tested are shown on Figures 3.6, 3.7 and. 3.8. All test sites failed to pressurize when air was introduced into the line. The conclusion was reached in the field that further air testing would not produce results that would enable the investigators to distinguish between the relative condition of the various sites tested, and therefore the air testing was halted and the investigating team proceeded with jet cleaning and televising of the lines. Refer to Appendix B for the Air Testing Standard Operating Procedure.

3.6 JET CLEANING AND IN-LINE VIDEOTAPING

Selected portions of the RMA sewer systems were televised by Guildner Pipeline Maintenance Inc. for MKE in December, 1985 and early January, 1986. Briefly stated, this procedure involved cleaning the segment of interest with a high pressure jet hose, stringing a cable between two consecutive manholes and pulling a black and white television camera through the lines to inspect and record the interior. This technique is a standard sewer maintenance procedure that locates trouble spots and permits in situ repairs without replacing whole sections of sewer line.

Refer to Appendix B for the Standard Operating Procedure for Jet Cleaning and Televising of Sewers. Table 3.4 summarizes the work accomplished in the low pressure air testing, jet cleaning and televising programs. Figures 3.6, 3.7 and 3.8 indicate the portions of the sewer systems that were jet cleaned and televised.

As demonstrated by Table 3.4, attempts at televising the contaminated sewer met with limited success. The portions of the abandoned South Plants contaminated sewers which were not flooded proved to be either so clogged with solids, partially broken or simply misaligned that the television camera assembly could not be pulled through the pipes in the few areas the jet

TABLE 3.4

SUMMARY OF SEWER TESTING WORK

	Sites Investigated	Contaminated	Sanitary	Other	Total
Air Testing	9 (2 invalid)	300'	600'	-----	900'
Jet Cleaning**	12	945'	1025'	300'*	2650'
Televising	6	139'	1009'	122'*	1270'

*Due to inadvertent entry into storm sewer system.

hose could pass through to string the cable. Other features that prohibited the televising of areas of interest were unorthodox sewer construction methods such as vertical and horizontal elbows that blocked the camera. Appendix C contains a summary of daily activities during the air testing and televising efforts.

In summary, seven sections of sewer were televised: contaminated sewer from manholes W22 to W21 (100 feet), W26 to W27 (7 feet), W21 to W17 (32 feet); sanitary sewer from manholes 117B to 119B (162 feet), S6 to S3 (357 feet) and 40 to 42 (490 feet). Also, 122 feet of 30-inch storm drain under December 7th Avenue was inadvertently televised. This line was initially mistaken for the original 1942 contaminated sewer main draining South Plant wastes to Basin A, but later jetting proved this assumption false when it was discovered the hose was actually in a newer storm drain.

No televising of the portion of the GB Plant contaminated sewer remaining in Section 36 was accomplished due to a lack of access at any two consecutive manholes.

4.0 PRELIMINARY CONCLUSIONS FROM PHASE I ACTIVITIES

The primary goal of Phase I of the RMA sewer investigations was the characterization of portions of the various sewer systems and subsequent selection of areas warranting additional investigation in Phase II. This goal was only partially realized. Due to the deteriorated condition of the South Plants contaminated sewer system, televising of this system was difficult and provided limited information from which to draw conclusions. The following discussion draws preliminary conclusions from the field observations and the review of the available Shell and Army drawings.

4.1 VIDEOTAPING

The videotaping effort provided the following information:

The 12-inch vitrified sewer between manholes W22 and W21 is in poor condition and probably represents original 1942 construction. Approximately 90 percent of the pipe joints are cracked, with the cracks ranging from hairline cracks to more severe breakage. There are approximately 32 joints over the 100 foot length of this sewer segment.

The repeated attempts to videotape the 12-inch line between manholes W26 and W27 resulted in taping only 7 feet of the 220 feet of contaminated sewer line. Entry was made from the north end. This portion of the line was flooded due to MKE's jet cleaning efforts, indicating vertical misalignment. The pipe entering through the wall of manhole W26 was not properly grouted, which allowed the jet cleaning nozzle to pass beside the pipe into the surrounding soils. The reason for obtaining only 7 feet of coverage was due to a buildup of residual sewer solids on the TV camera skids that eventually blocked the lens and prohibited camera travel. These solids continued to block the camera after repeated attempts at cleaning the line with the sewer jetting equipment.

Only 32 feet out of the total 165 feet of 6-inch clay sewer between contaminated manholes W21 and W17 was successfully televised. This line, constructed in 1957, has vertical alignment problems as evidenced by water standing in the pipe 22 feet from manhole W21. Prior to submerging the camera in this water, each pipe joint was observed to be offset, some quite severely. The camera halted at 32 feet from manhole W21 due to the inability of the camera skids to clear a particularly severe offset joint.

The three sections of contaminated sewer discussed above were the only portions of contaminated sewer successfully televised. Attempts were made to inspect other parts of the contaminated system, but field conditions prohibited successful investigation. Refer to Appendix C for a detailed summary of all attempts at televising the contaminated sewer.

As expected, the sanitary sewer system proved to be more readily inspected than the contaminated sewer. Television inspection of the segment between 117B and 119B indicated that two areas were broken, one of which had pipe fragments in the bottom of the pipe. Also, 16 offset joints were observed out of a total of approximately 53 joints. This segment of sewer is probably original 1942 construction.

In the Chlorine Plant area, 357 feet of 8-inch sanitary sewer from manholes S3 to S6 were televised. This portion of the system, considered to be original 1942 construction, appeared to be in better condition than the 117B to 119B segment. Offset joints were observed, although not as severe as the previously discussed areas. Longitudinal cracks were observed running from 105 to 108 feet, 111 to 114 feet and 177 to 180 feet from manhole S6.

In Section 26, 490 feet of 12-inch sanitary sewer between manholes 40 and 42 were televised to provide an indication of conditions outside of the South Plants. Although pipe alignment appeared to be poor based on observed pipe joint offsets, no pipe breakage was observed.

4.2 MANHOLE CONDITION

As shown by Figures 3.1, 3.2 and 3.3, South Plants manholes are constructed with brick, precast concrete and cast-in-place concrete. Since original RMA manholes were constructed with brick, concrete construction is an indication of more recent activity. Precast concrete manholes are probably an indication of the most recent construction.

Inspection of manholes by MKE field personnel indicated that most of the contaminated sewer brick manholes have experienced severe chemical corrosion. Typical observed conditions were corroded metal rungs (oftentimes completely missing), missing mortar between bricks and, in extreme instances, partially eroded brick work or collapsing manhole walls due to an excessive removal of mortar. All observed manholes were photographed for documentation.

Inspection of manholes in the sanitary sewer system indicated that, for the most part, they were in fair condition considering the years of service. This is confirmed by the 1979 Memorandum Report by Black & Veatch.

Upon entry of contaminated manholes W21, W22, W24, W25 and W26, Guildner Pipeline Maintenance personnel expressed their uncertainty that the manholes had competent bottoms. Further inspection showed that the manhole inverts were sometimes constructed with brick and mortar and typically appeared to have eroded bottoms filled with soil. MKE field personnel hammered a probe into the manhole bottoms and in each case struck a solid

surface within a foot below the invert. A review of Army Drawing 7164-2003, "Typical Details of Service Connections and Manholes", shows that the original manhole bottoms were not as deep as shown by the MKE field inspection.

4.3 POSSIBLE CONTAMINANT SOURCES FROM SEWERS

In addition to the various sewer-related contaminant transport mechanisms recognized in the Army literature, the MKE review of Army drawings and actual field conditions indicate some additional possibilities. The following summarizes these instances and it is anticipated that further investigation will yield others. Refer to Figures 3.1, 3.2 and 3.3.

4.3.1 Sewer Cross-Over Locations

- Drawing D6-3-1 shows two locations where contaminated lines from the mustard demil area (Buildings 536, 537 and 538) cross above the sanitary line between manholes SA-1 and SA-2.

- Drawing A-8/456.15B/A-1 shows approximately 150 feet of contaminated sewer running parallel to and over the sanitary sewers out of Building 522.

- Drawing E2-18-4 shows a contaminated line servicing the laundry and laboratory (Buildings 314 and 313) crossing over the sanitary sewer between manholes 106 and 105 and running north along "D" Street.

- Drawing 71-07-11, Sheet 1, shows the close proximity of the contaminated sewer draining the 1953 dichloro production area with the sanitary sewer running north out of MH 121. Also, the original 42-inch cooling water return line discharging to Upper Derby Lake runs underneath the contaminated line in this location. Shell

and Army documents indicate that this area of the South Plants has seen cross contamination of the sanitary sewer and cooling water return systems by acidic wastes from the contaminated sewer.

- Drawing E6-5-1 shows a contaminated sewer line built by the Army in 1957 crossing over the existing sanitary line between sanitary manholes 117B and 117A. This contaminated line served the Army laundry and laboratory.

4.3.2 Chlorine Plant Contaminated Sewer Cross Connection

As detailed on Figure 3.1, a cross-connection exists between the original Chlorine Plant contaminated sewer and the 1956 contaminated sewer constructed by the Army along with Basin F. The connection was designed to operate as follows:

Waste and storm water flowing south out of manhole I-2 passed through a 20-inch line to the next downstream manhole and, by the installation of a baffle in this manhole, was diverted to a lift station that pumped the liquid north to a brick stilling basin. From this point the waste flowed north in the new gravity sewer on to Basin F. The details of this cross-connection are depicted by Army Drawing 71-17-01, Sheet 13.

MKE field personnel have located and photographed this arrangement. The baffle installation is a 1/4-inch steel plate that is keyed into the walls of the manhole and extends approximately three feet from the bottom of the manhole. In the event of either lift station mechanical problems, electrical problems or excessive sewer flows due to storm water, the effluent would overflow the baffle and continue on to the south and Sand Creek Lateral. The time frame of such overflows would be that of the GB-brine chlorine production experimental program from 1956 to 1957. This arrangement could also result in flows to Sand Creek Lateral after the Chlorine Plant was abandoned.

At present, the baffled manhole is silted up to the top of the steel plate, as are several of the other manholes in the Chlorine Plant area.

4.3.3 M-1 Settling Basins

The M-1 Settling Basins, shown on Figures 3.2 and 3.3, were partially below-grade basins first used by the Army in 1943. These basins received slurried Lewisite process wastes, the solids were settled and the liquid decanted into the main 30-inch sewer that ultimately crossed December 7th Avenue and discharged into unlined Basin A. Originally, two basins were built immediately south of December 7th Avenue. After these filled with solids, a third M-1 Basin was built in 1943 on the east side of the first two.

The three M-1 Settling Basins received Lewisite plant washdown, spills and off-spec material after the wastes were treated with lime in the decontamination reactors (Building 513). The basins also received wastes from the Acetylene Generation Building, the Thionyl Chloride Plant and the Arsenic Trichloride Plant. These unlined earthen structures are shown on early RMA drawings.

As reported in the RMA History, approximately 183,000 lbs. of mercuric chloride catalyst were discharged into the M-1 Settling Basins through November of 1943. In his deposition, George Donnelly describes his proposal to the Arsenal at that time to excavate the M-1 Basins and retort the waste to recover the mercury, some of which was actually recoverable in its elemental form from the ground surface. His request was denied, and the basins to this day remain covered with a few feet of dirt and gravel.

A review of Army drawings shows that the bottom elevation of the M-1 Basins is 5256.8. The sanitary sewer line immediately to the north of and adjacent to the M-1 Basins is shown

approximately two feet lower, with manhole 101 at an invert elevation of 5254.6 and manhole 102 at 5255.4. Shell water level data taken between September 1979 and September 1985 indicates that groundwater elevations in the M-1 area have ranged from a high of 5257.8 (one foot higher than the M-1 Basins bottom and 2.8 feet above the sewer) to a low of 5254.4 (2.4 feet below the M-1 Basins and 0.6 feet below the sewer). The data shows that in this time period the groundwater level was typically over the sanitary sewer and just below the M-1 Basins.

5.0 SELECTION FOR PHASE II EXCAVATION

The overall objective of the Phase I investigation of the RMA sewer systems was to provide additional information for the selection of sites for excavation, observation and sampling. In spite of the limited success in the televising of the contaminated sewers, this goal was achieved. A review of the operational history of the sewers, the 1979 and 1980 Black & Veatch sanitary sewer reports and the knowledge gained thus far in the Phase I investigation resulted in the selection of 17 candidate sites for additional investigation and possible excavation. These sites are described in Table 5.1. Figures 3.6, 3.7 and 3.8 show site locations.

The candidate sites have been surveyed and staked in the field; and RMA Facilities Engineer and MKE personnel have inspected the sites together. Possible interference with water and gas lines may eliminate some sites from further consideration. Other sites, specifically 8 and 15, have interference from overhead steam lines that may inhibit excavation.

The first 17 candidate sites listed in Table 5.1 have been discussed with USATHAMA and RMA personnel. In addition to these sites, Site 18 has been added to this list to allow for the possibility of investigating the sanitary sewer between manholes 101 and 102. Groundwater elevation readings of the Shell monitoring wells scheduled to be made in May will determine if this site will be sufficiently dry to allow excavation.

TABLE 5.1 - CANDIDATE RMA SEWER EXCAVATION SITES

Site #	Sewer Type	Description of Site	Year Built	Reason for Excavating	Depth Below Grade	Ground Surface & *Groundwater Elevation	Relevant Drawings	Comments
1	Contaminated V.C.P. (Vitrified Clay Pipe)	10" line between MH W29 & MH W28, SE of Bldg. 431, excavate near MH 29.	1942	Failed air test, jet hose stopped approx. 10' E of W29. Downstream of Dichloro Prod. Area. No pavement. Near 1952 acid leak.	~4'	Ground elevation @ 5270 per 1962 topo. Water at ~5260+.		Potable water & process water lines run north-south.
2	Contaminated V.C.P.	10" line between MH W25 & MH W26, excavate where most accessible.	1942	On main trunk, near phossy water explosions in early 1950's, good access off pavement. Low ground. Failed air test.	~7'	Ground @ 5270 per 1960 topo. Water at 5260+.		10" water line runs perpendicular to sewer. Should clear.
3	Contaminated V.C.P.	10" line running N. out of MH W25.	1942	On main trunk, near phossy explosions in early 1950's. Possible access North of RR.	~9'	Ground @ 5270 per 1962 topo. Water at 5260+.		10" water line near site.
4	Contaminated V.C.P.	12" line between MH W21 & MH W22. Should have a portion NOT under pavement.	1942	Guildners TV'ing showed most joints are cracked. On main trunk.	~9'	Ground @ 5270 per 1962 topo. Water at 5260+.	E6-5-1	10" water line near site.
5	Contaminated V.C.P.	6" line from MH W21 to MH W17. Portion NOT under pavement near W21.	1957	TV'ing showed low area holding water near MH W21. This line carried waste from the lab and laundry.	~7'	Ground elevation @ 5270 @ MH 21. Water at 5260+.	E6-5-1	Army to remove red shed on site.

TABLE 5.1 - Continued (WP-12301)

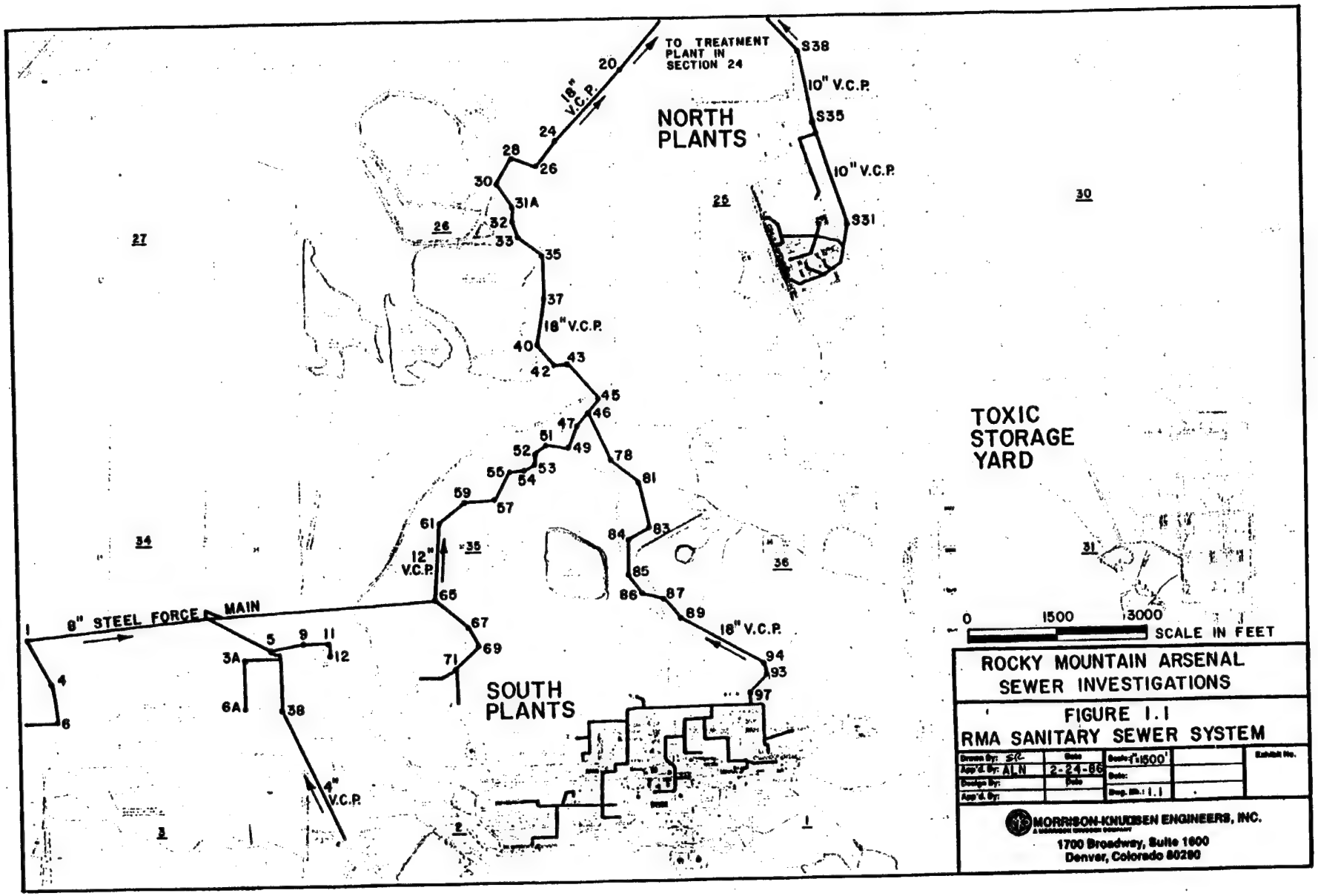
Site #	Sewer Type	Description of Site	Year Built	Reason for Excavating	Depth Below Grade	Ground Surface & *Groundwater Elevation	Relevant Drawings	Comments
6	Contaminated V.C.P.	12" line N. of MH W21 toward W16. A portion NOT under pavement.	1942	Presumably as bad as MH W21 through MH W22. On main trunk.	~7'	Ground elevation @ 5270 @ MH 21. Water at 5260+.	7164-2032	Good access.
7	Contaminated (never used?) V.C.P.	12" line running into caustic basin, Sec. 35.	1942	Presumably a "virgin" 1942 line that would show construction techniques, COULD BE LAID 180° BACKWARDS.	~5'	Ground elevation at ~5260 per 7164-2032. Water at ?	7164-2032	Good access, open area.
8	Sanitary V.C.P.	2 possible spots on line from 117B to 119B.	1942	TV'ing showed two cracked spots that may signify bedding/backfill problems.	~10'	Ground elevation ~5270.5 per 7164-2013. Water at 5260+.	7164-2013 SK-419	10" water main, 2" gas line plus overhead steam.
9	Contaminated V.C.P.	East of Bldg. 412.	1942	Area impacted by Dichloro Production.	~4'	Ground @ 5270 per 1962 topo. Water at 5260-.		Good site.
10	Sanitary V.C.P.	Line N. of MH 121, which is plugged. Off edge of road in ditchline.	1942	Shell documents show acid from Dichloro wastes got into this line. (Should dig near contaminated line).	~6'	Ground elevation at 5270. Water at 5260+.	71-07-11, Sheet 1	Nearby water line on road shoulder. Should be OK.
11	Contaminated V.C.P.	N. Plants contaminated sewer in Sec. 36, downstream of force mains. (Probably upsteam of MH 5-3).	1957	Apparent sink-holes along pipeline. Historic area of unaccounted for losses. MH 5-3 has silty mud & water, therefore excavate upstream of MH.	~5'	Ground elevation average @ 5250. Water at ?	71-17-01, Sheets 8 & 9.	Open site.

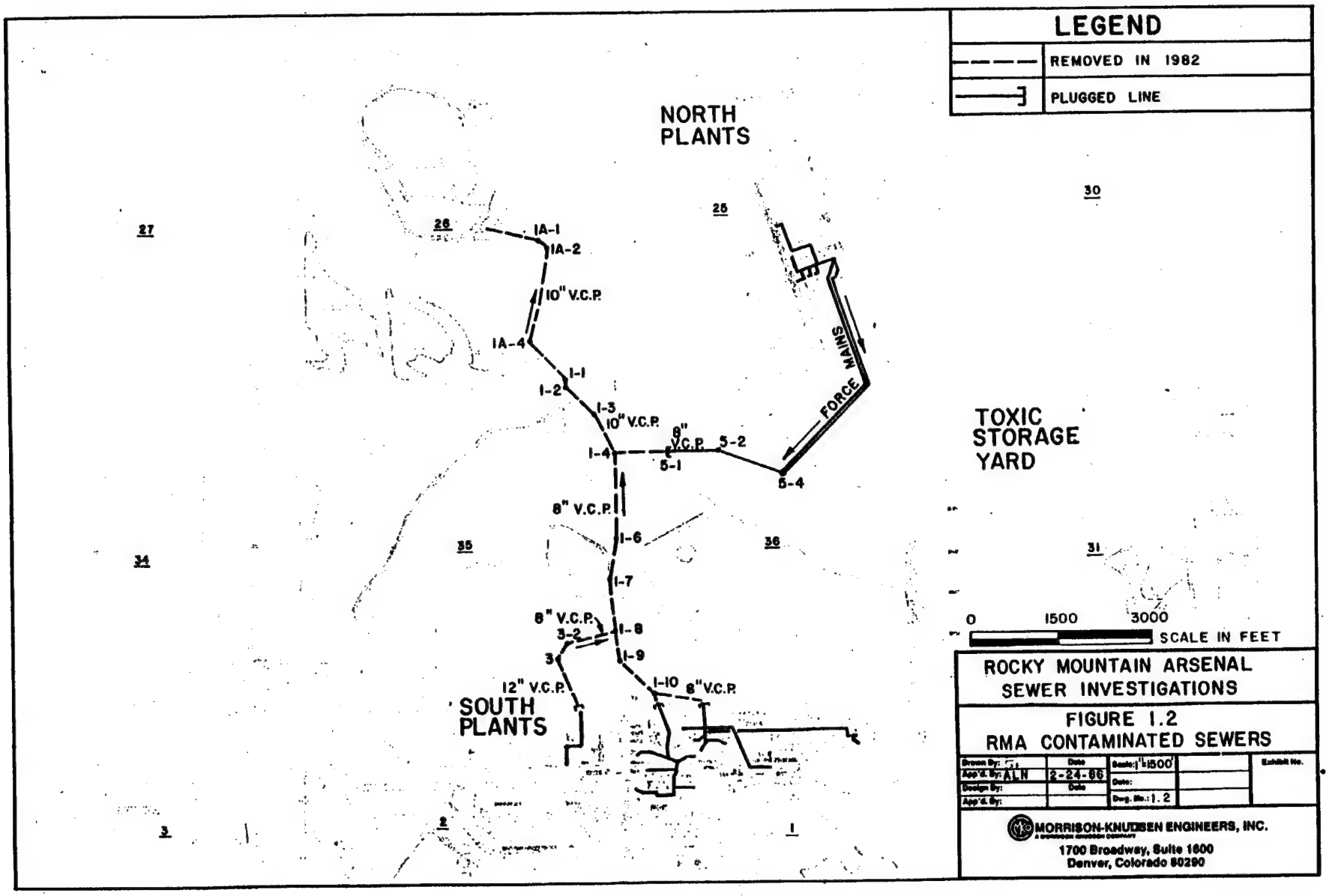
TABLE 5.1 - Continued (WP-12301)

Site #	Sewer Type	Description of Site	Year Built	Reason for Excavating	Depth Below Grade	Ground Surface & *Groundwater Elevation	Relevant Drawings	Comments
12	Sanitary V.C.P.	18" line near manhole 40 on main SS trunk, Sec. 26.	1942	Nothing of interest on TV, but is near site of "temporary septic tank".	~9'	Ground elevation @ 5225 per 1962 topo. Water at ?		Open site.
13	Sanitary V.C.P.	8" line South of Bldg. 321, 160' South of MH 110.	1942	Guildner TV'd in 1980 & showed the top of pipe missing.	< 5'	Ground elevation @ 5272 per 1962 topo. Water at 5256.		Stearns-Roger to move scrap. 16" water line on road shoulder. Contaminated sewer to North.
14	Sanitary V.C.P.	6" line South of 536, 230' East of manhole SA-2.	10/1948	1980 TV work shows that TV camera fell into a "gap" in bottom of pipe.	~5'	Ground elevation @ 5266 per 1962 topo. Water at 5259.	D6-3-2	Water line nearby. Area of earlier sewer repair.
15	Sanitary V.C.P.	6" line North of Bldg. 543, ~15' N. of MH SA-4.	10/1948	1980 TV work showed "crushed pipe"; could be due to RR loading.	~5'	Water @ ~5258. Ground @ 5268.	D6-2-3 D6-3-2	Could be too close to RR, overhead pipe interference.
16	Sanitary V.C.P.	12" line 226' North of MH 106.	1942	1980 TV work shows "top of pipe missing".	~9'	Ground @ 5268 per 1962 topo. Water at 5259.	E2-18-4	36" water line, plus others. Busy site.
17	Sanitary V.C.P.	6" line North of Bldg. 344, 114' East of MH 111I.	1944-1945	1980 TV work shows "crushed pipe".	~7'	Ground elevation @ 5258 per 1962 topo. Water at < 5250.	456.6E/ A-1	16" water line between road & building, parallel to sewer. Also a gas line.
18	Sanitary V.C.P.	12" line between MH 101 and MH 102.	1942	Potential infiltration site from bottom of M-1 Basins, per 1980 TV work.	~9'	Ground @ 5264 Groundwater elevation at ~5254±.		Depends on groundwater elevation.

*Water elevations based on September 1985 data.

LIST OF FIGURES


TO TREATMENT PLANT IN SECTION 24
NORTH PLANTS
SOUTH PLANTS
TOXIC STORAGE YARD
8" STEEL FORCE MAIN
18" V.C.P.
10" V.C.P.
12" V.C.P.
4" V.C.P.
S38
S35
S31
20
24
28
26
30
31A
32
33
35
37
40
42
43
45
46
47
51
49
78
81
52
53
55
54
59
57
61
84
83
85
86
87
89
94
93
97
65
67
69
71
1
3A
5
9
11
12
4
6
6A
38
27
26
25
30
34
35
36
31
3
2
1
0
1500
3000
SCALE IN FEET
ROCKY MOUNTAIN ARSENAL
SEWER INVESTIGATIONS
FIGURE 1.1
RMA SANITARY SEWER SYSTEM
Drawn By: SIC
App'd. By: ALN
Design By:
App'd. By:
Date
2-24-66
Date
Scale: 1"=1500'
Date:
Dwg. No.: 1.1
Exhibit No.
MORRISON-KNUDSEN ENGINEERS, INC.
1700 Broadway, Suite 1600
Denver, Colorado 80290


LEGEND
REMOVED IN 1982
PLUGGED LINE
NORTH PLANTS
SOUTH PLANTS
TOXIC STORAGE YARD
FORCE MAINS
IA-1
IA-2
10" V.C.P.
IA-4
I-1
I-2
I-3
10" V.C.P.
8" V.C.P.
5-2
5-1
5-4
I-4
8" V.C.P.
I-6
I-7
8" V.C.P.
3-2
I-8
I-9
3
12" V.C.P.
I-10
8" V.C.P.
26
25
30
27
35
36
31
34
3
2
1
0
1500
3000
SCALE IN FEET
ROCKY MOUNTAIN ARSENAL
SEWER INVESTIGATIONS
FIGURE 1.2
RMA CONTAMINATED SEWERS
App'd. By: ALN
2-24-86
Scale: 1"=1500'
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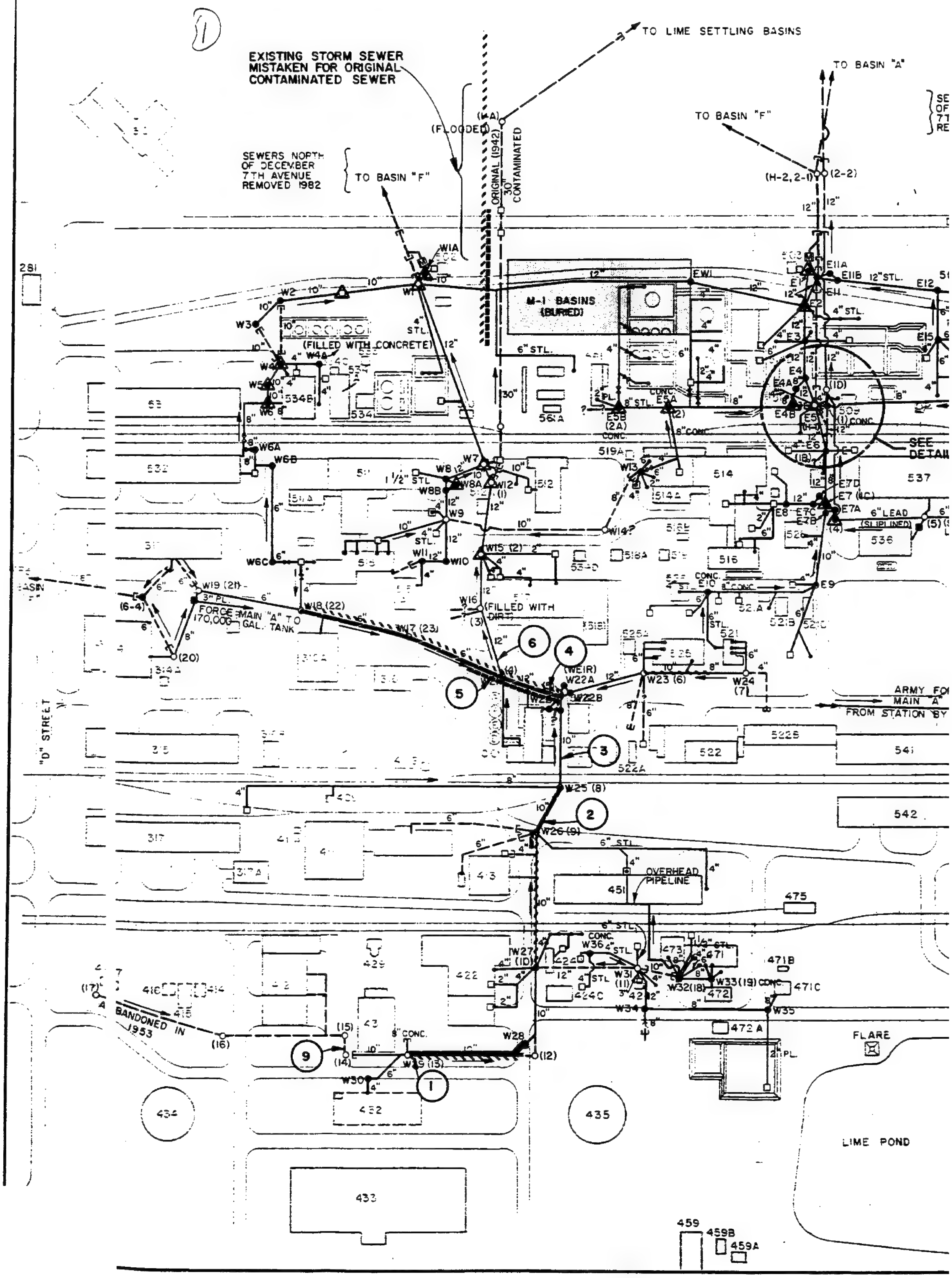
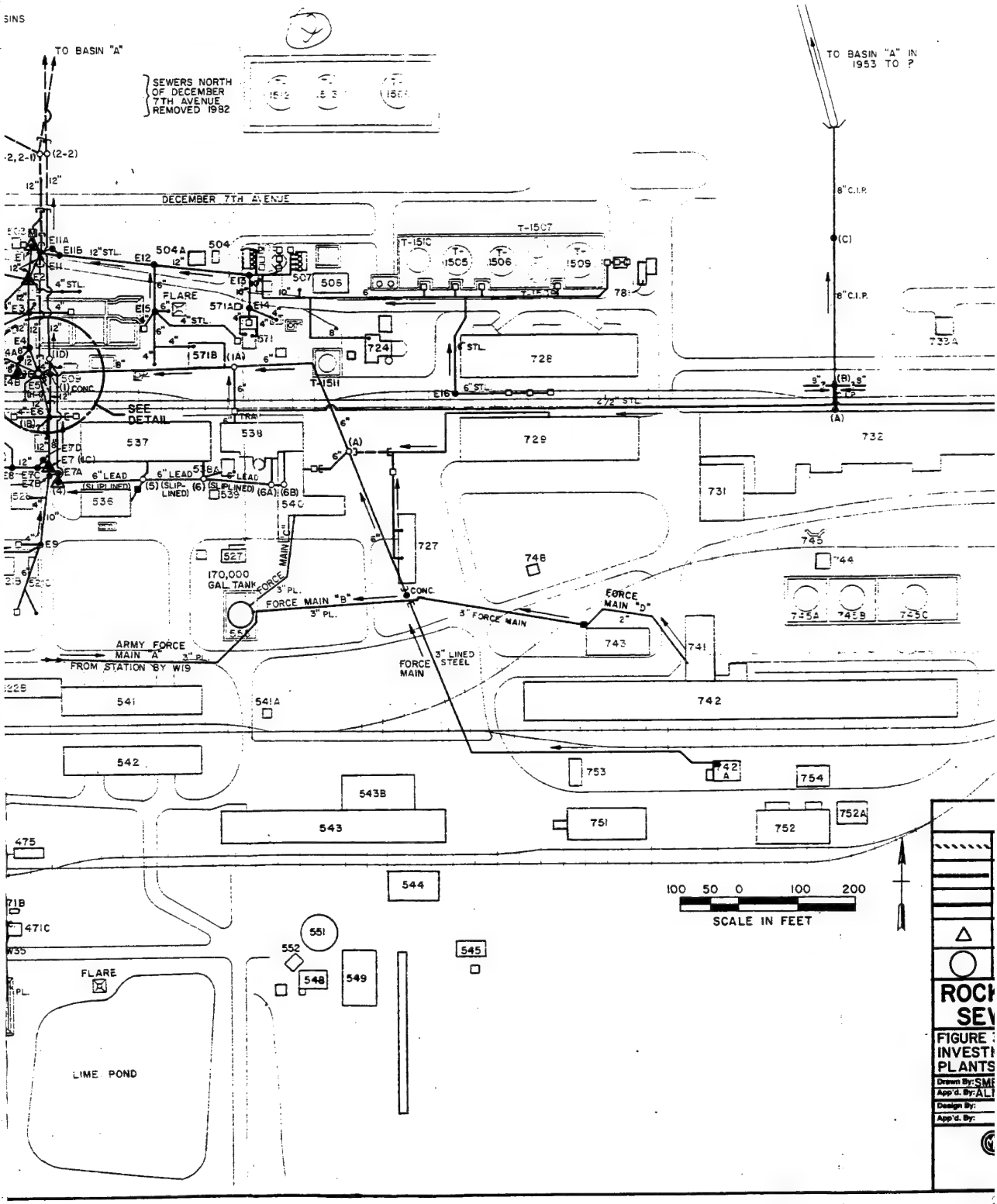
MORRISON-KNUDSEN ENGINEERS, INC.
1700 Broadway, Suite 1600
Denver, Colorado 80290



EXISTING STORM SEWER MISTAKEN FOR ORIGINAL CONTAMINATED SEWER
TO LIME SETTLING BASINS
TO BASIN "A"
TO BASIN "F"
SEWERS NORTH OF DECEMBER 7TH AVENUE REMOVED 1982
ORIGINAL (1942) 30" CONTAMINATED
M-1 BASINS (BURIED)
(FILLED WITH CONCRETE)
(FILLED WITH DIRT)
FORCE MAIN "A" TO 170,000 GAL. TANK
"D" STREET
ARMY FORCE MAIN "A" FROM STATION
OVERHEAD PIPELINE
ABANDONED IN 1953
FLARE
LIME POND
SEE DETAIL


SINS
TO BASIN "A"
SEWERS NORTH OF DECEMBER 7TH AVENUE REMOVED 1982
TO BASIN "A" IN 1953 TO ?
DECEMBER 7TH AVENUE
8" C.I.P.
FLARE
SEE DETAIL
170,000 GAL TANK
FORCE MAIN "B"
3" PL.
3" FORCE MAIN
FORCE MAIN "D"
2"
ARMY FORCE MAIN "A" 3" PL.
FROM STATION 'BY W19
3" LINED STEEL
FORCE MAIN
LIME POND
SCALE IN FEET
100 50 0 100 200
504
504A
505
507
724
727
728
729
731
732
733A
735A
735B
735C
737
738
739
740
741
742
743
744
745
746
748
751
752
752A
753
754
536
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541
542
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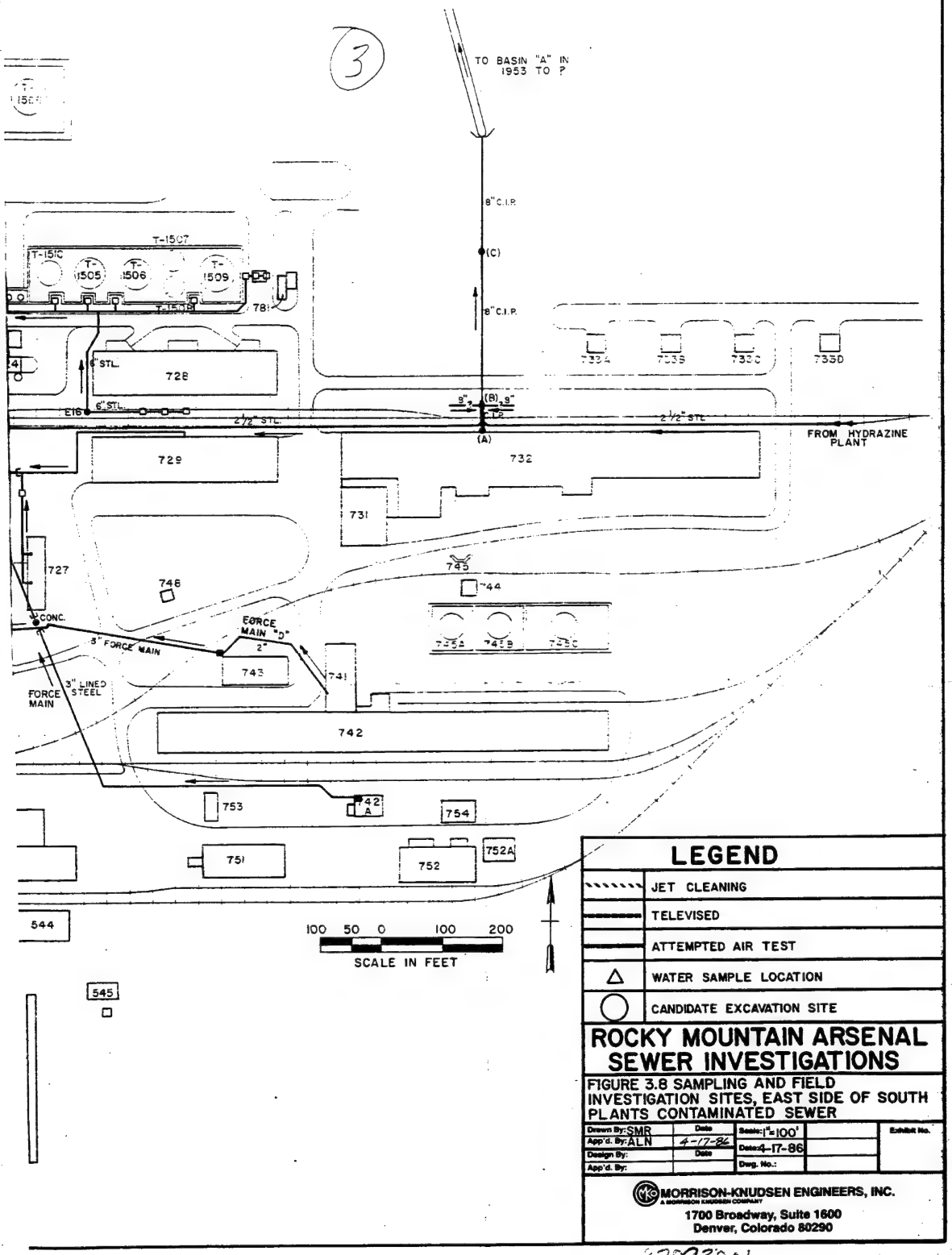
543B
544
545
548
549
551
552
527
475
471C



LEGEND

~~	JET CLEANING
———	TELEVISED
———	ATTEMPTED AIR TEST
△	WATER SAMPLE LOCATION
◯	CANDIDATE EXCAVATION SITE

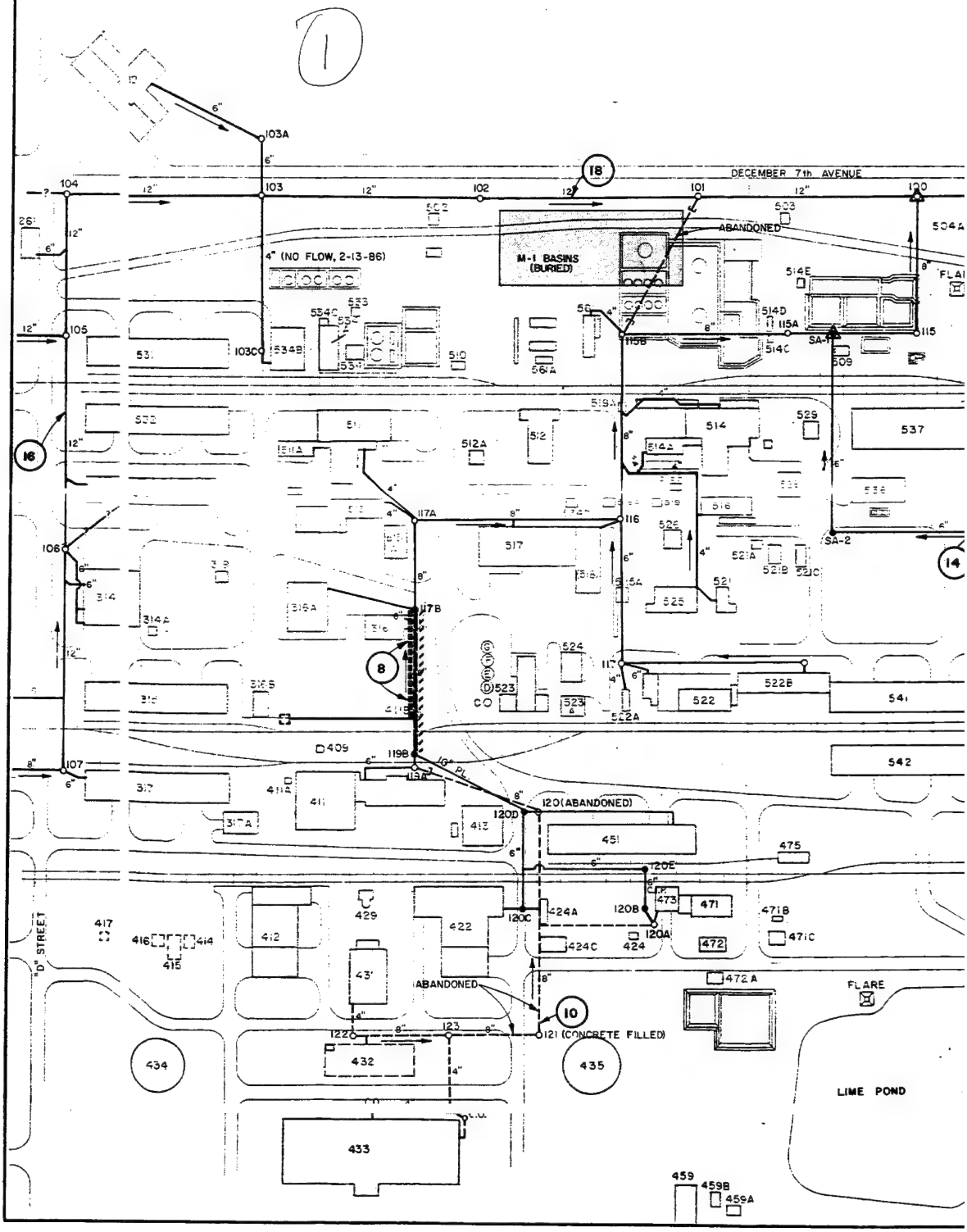
ROCKY MOUNTAIN ARSENAL SEWER INVESTIGATIONS

FIGURE 3.8 SAMPLING AND FIELD INVESTIGATION SITES, EAST SIDE OF SOUTH PLANTS CONTAMINATED SEWER

Drawn By: SMR	Date	Scale: 1"=100'		Exhibit No.
App'd. By: ALN	4-17-86	Date: 4-17-86		
Design By:	Date	Dwg. No.:		
App'd. By:				

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY
1700 Broadway, Suite 1600
Denver, Colorado 80290

67093R01


DECEMBER 7th AVENUE
ABANDONED
M-1 BASINS (BURIED)
4" (NO FLOW, 2-13-86)
103A
104
103
102
101
100
105
106
107
103C
115A
115B
115
116
117A
117B
118A
119A
120 (ABANDONED)
120A
120B
120C
120D
120E
121 (CONCRETE FILLED)
122
123
SA-1
SA-2
FLARE
LIME POND
"D" STREET
16" PL
18
16
14
10
8
434
435
531
532
533
534B
534C
534D
510
511
512
512A
514
514A
514B
514C
514D
514E
516
516A
517
521
521A
521B
521C
522
522A
522B
523
523A
524
525
526
529
537
538
541
542
309
314
314A
316
316A
316B
317
317A
409
411
411A
412
413
415
416
417
422
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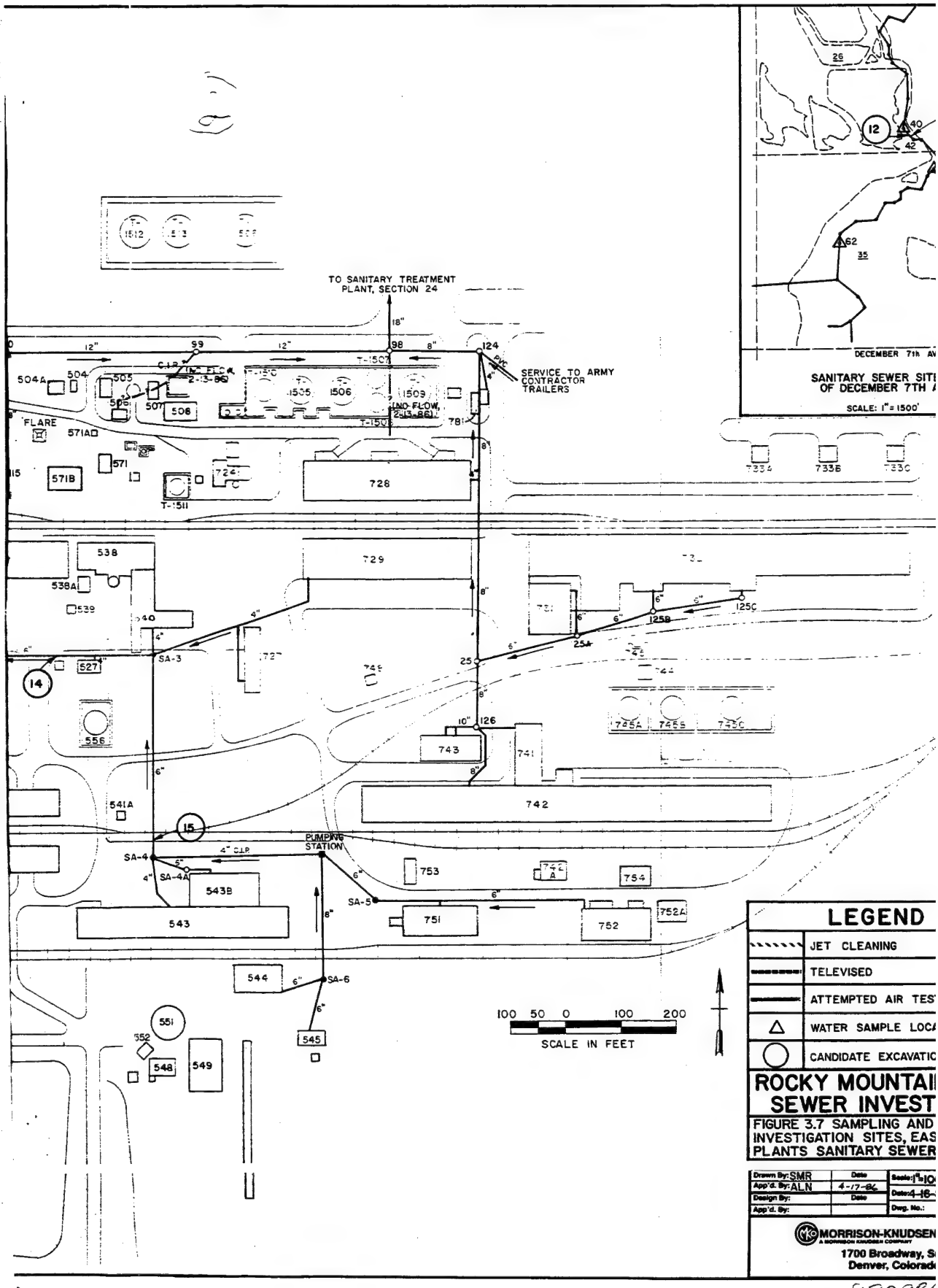
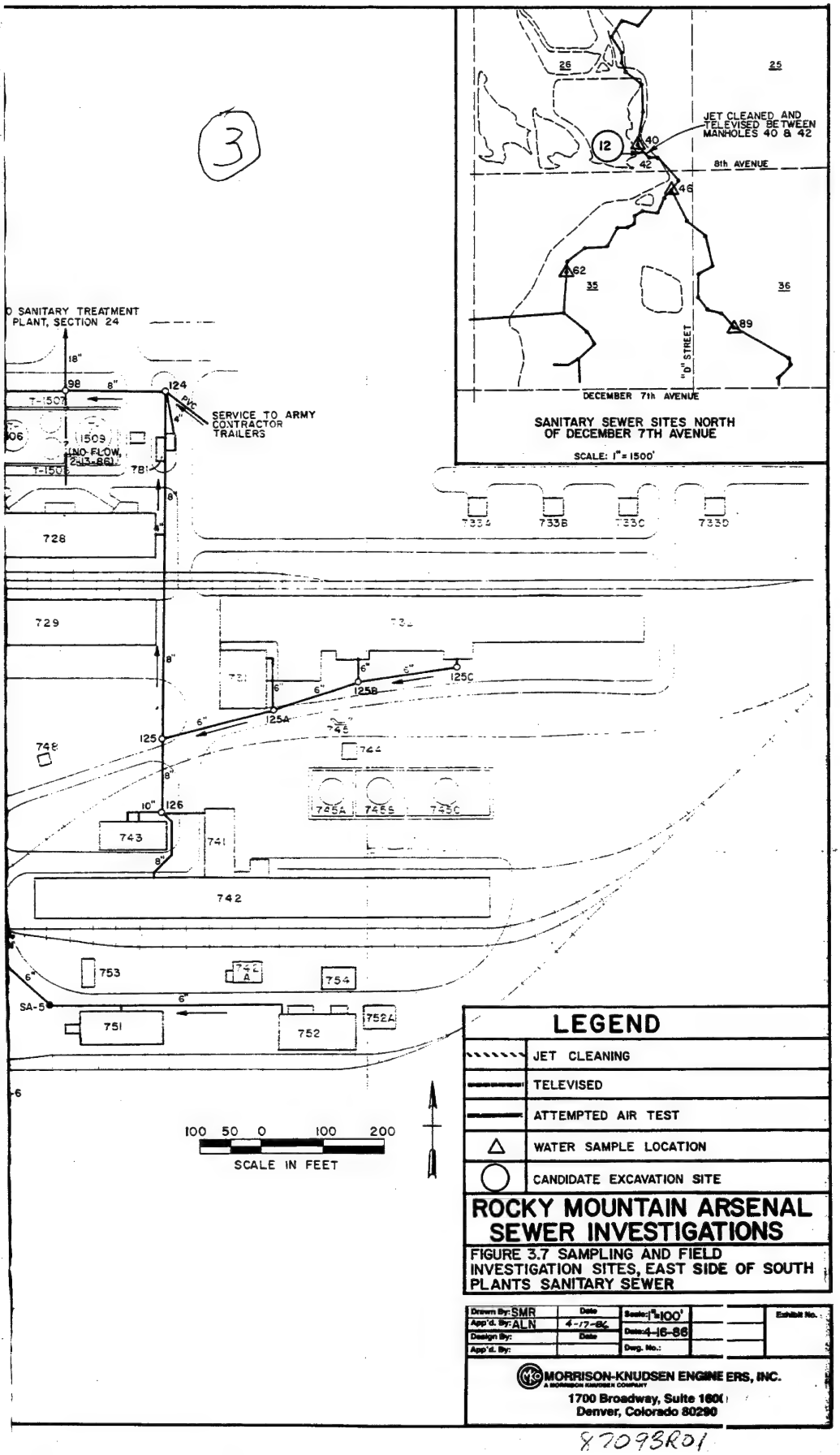
459B
471
471A
471C
472
472A
473
475


TO SANITARY TREATMENT PLANT, SECTION 24
SERVICE TO ARMY CONTRACTOR TRAILERS
FLARE
PUMPING STATION
SA-3
SA-4
SA-4A
SA-5
SA-6
4" C.I.P.
(NO FLOW 2-13-86)
(NO FLOW 2-13-86)
SCALE IN FEET
100 50 0 100 200
DECEMBER 7th AV
SANITARY SEWER SITI
OF DECEMBER 7TH A
SCALE: 1" = 1500'
LEGEND
JET CLEANING
TELEVISED
ATTEMPTED AIR TES
WATER SAMPLE LOCA
CANDIDATE EXCAVATIO
ROCKY MOUNTAI
SEWER INVEST
FIGURE 3.7 SAMPLING AND
INVESTIGATION SITES, EAS
PLANTS SANITARY SEWER
Drawn By: SMR
App'd. By: ALN
Design By:
App'd. By:
Date
4-17-86
Date
Scale: 1" = 10
Date: 4-16-
Dwg. No.:
MORRISON-KNUDSEN
1700 Broadway, S
Denver, Colorad

870986


3
SANITARY TREATMENT PLANT, SECTION 24
SERVICE TO ARMY CONTRACTOR TRAILERS
(NO FLOW, 2-13-86)
T-1507
T-1506
1509
1508
728
729
731
732
733A
733B
733C
733D
734
735A
735B
735C
741
742
743
744
745
748
751
752
752A
753
754
SA-5
125
125A
125B
125C
126
JET CLEANED AND TELEVISED BETWEEN MANHOLES 40 & 42
8th AVENUE
"D" STREET
DECEMBER 7th AVENUE
SANITARY SEWER SITES NORTH OF DECEMBER 7TH AVENUE
SCALE: 1" = 1500'
100 50 0 100 200
SCALE IN FEET
LEGEND
JET CLEANING
TELEVISED
ATTEMPTED AIR TEST
WATER SAMPLE LOCATION
CANDIDATE EXCAVATION SITE
ROCKY MOUNTAIN ARSENAL SEWER INVESTIGATIONS
FIGURE 3.7 SAMPLING AND FIELD INVESTIGATION SITES, EAST SIDE OF SOUTH PLANTS SANITARY SEWER
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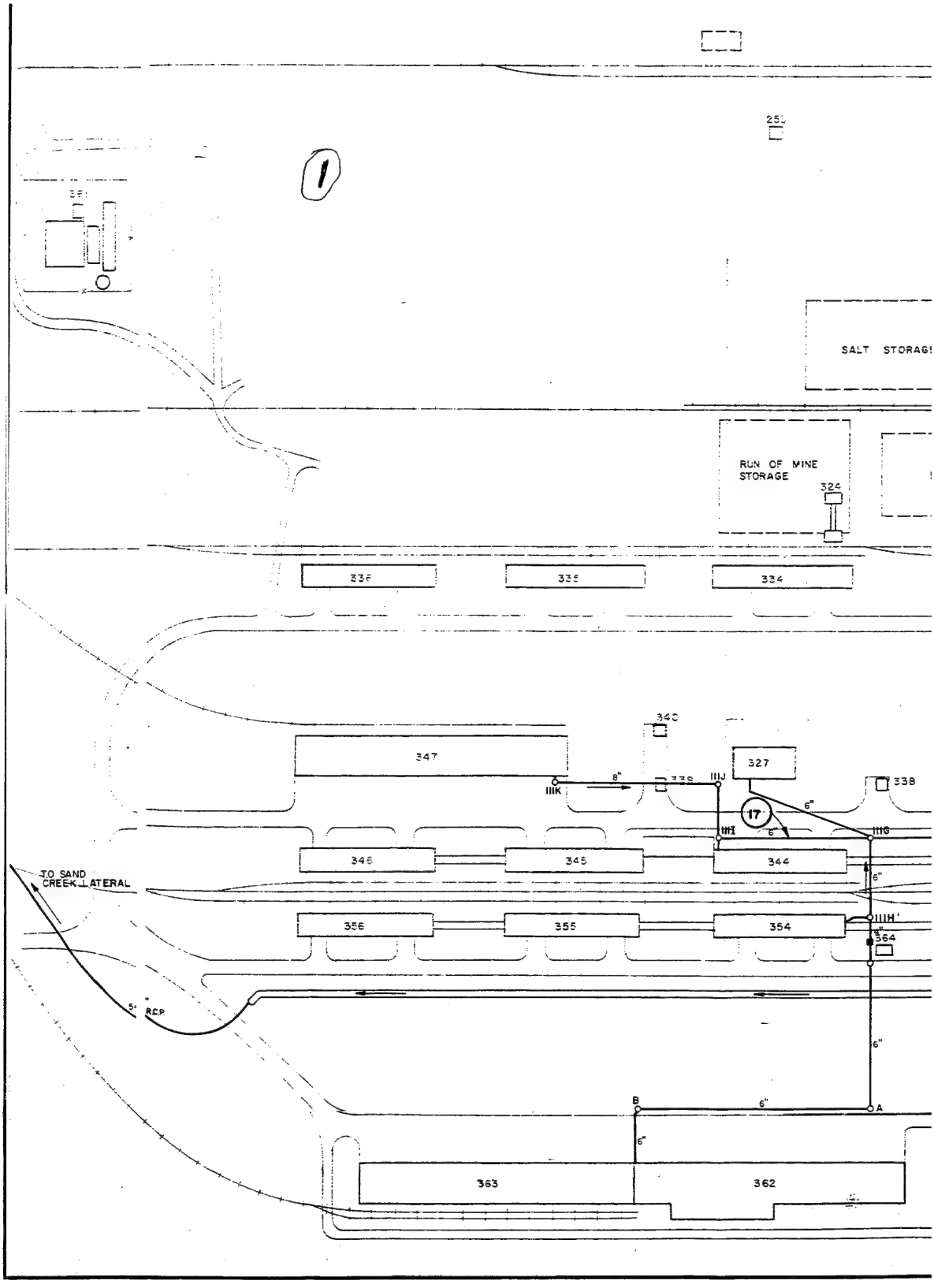
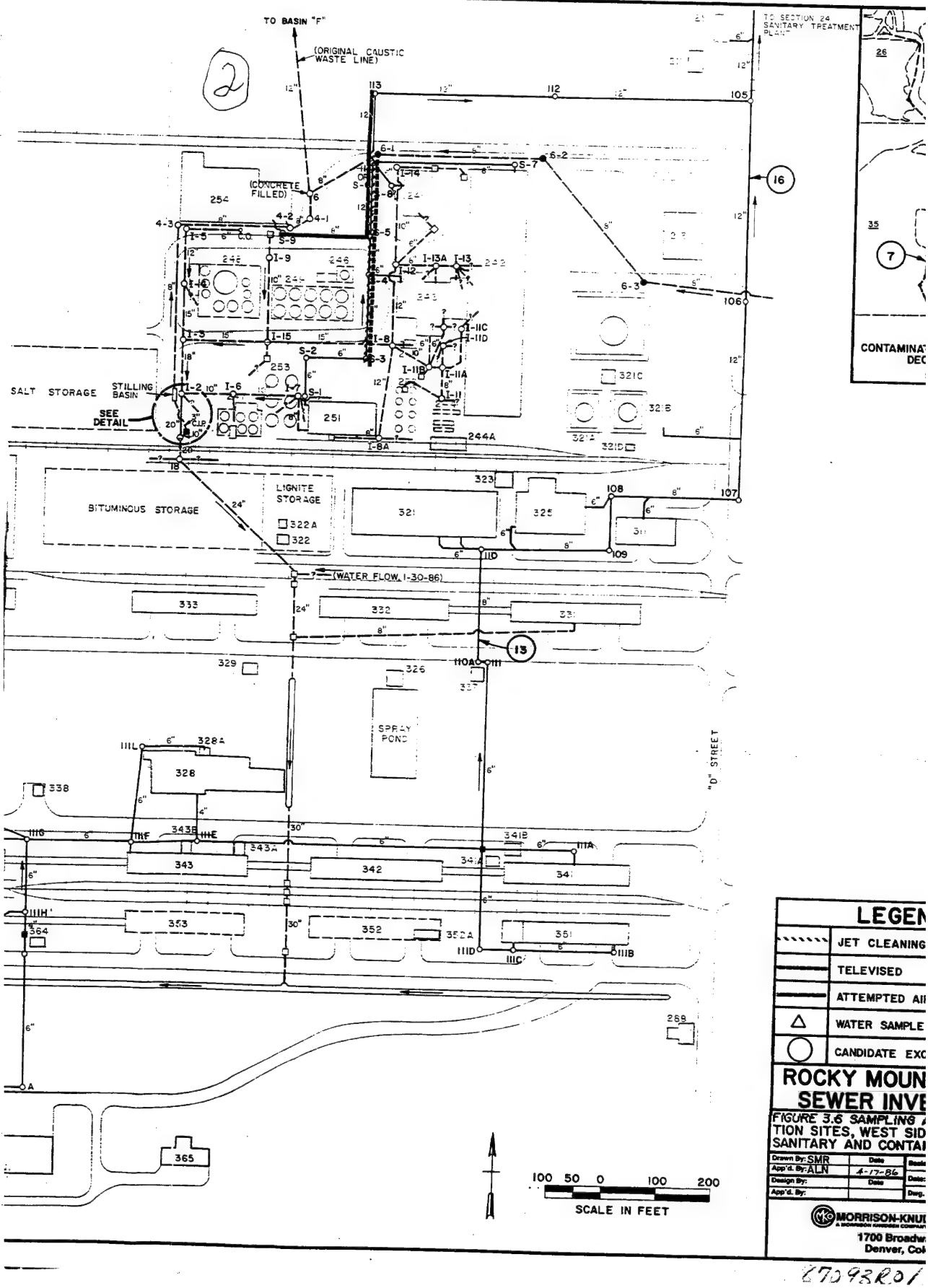
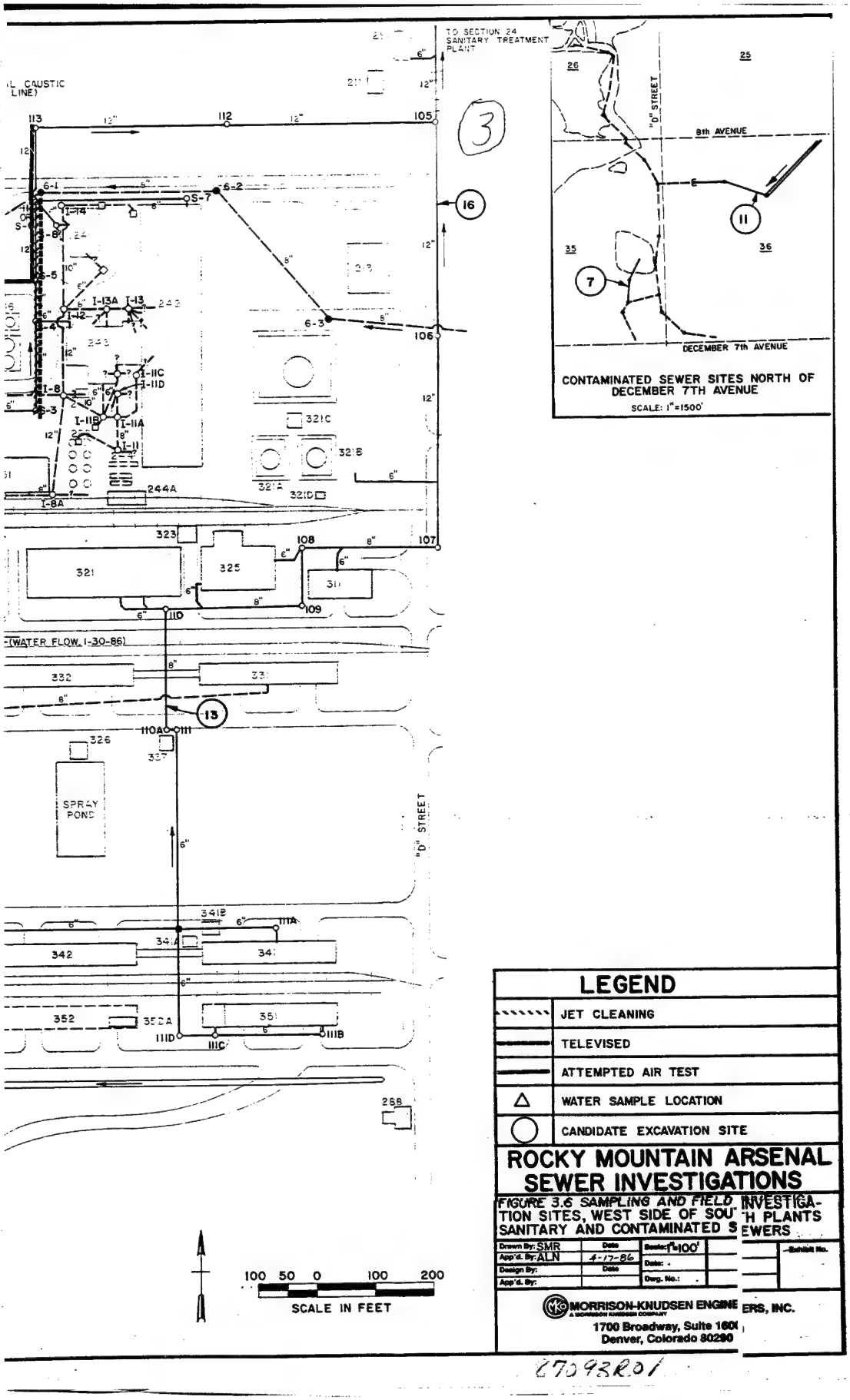
App'd. By: ALN
Date: 4-17-86
Design By:
App'd. By:
Scale: 1"=100'
Date: 4-16-86
Dwg. No.:
Exhibit No.
MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY
1700 Broadway, Suite 1600
Denver, Colorado 80290

87093R01


SALT STORAGE
RUN OF MINE STORAGE
324
336
335
334
340
347
327
338
8"
6"
17
348
345
344
356
355
354
364
TO SAND CREEK LATERAL
54" RCP
B
A
363
362


TO BASIN "F"
(ORIGINAL CAUSTIC WASTE LINE)
2
TO SECTION 24 SANITARY TREATMENT PLANT
(CONCRETE FILLED)
SALT STORAGE
STILLING BASIN
SEE DETAIL
BITUMINOUS STORAGE
LIGNITE STORAGE
322A
322
(WATER FLOW, 1-30-86)
SPRAY POND
"D" STREET
CONTAMINAT
DEC
LEGEN
JET CLEANING
TELEVISED
ATTEMPTED AI
WATER SAMPLE
CANDIDATE EXC
ROCKY MOUN
SEWER INVE
FIGURE 3.6 SAMPLING
TION SITES, WEST SID
SANITARY AND CONTA
Drawn By: SMR
App'd. By: ALN
Date 4-17-86
Design By:
App'd. By:
MORRISON-KNU
1700 Broadw
Denver, Col
100 50 0 100 200
SCALE IN FEET

CTD98R01



CONTAMINATED SEWER SITES NORTH OF DECEMBER 7TH AVENUE

SCALE: 1"=1500'

LEGEND

- JET CLEANING
- TELEVISED
- ATTEMPTED AIR TEST
- △ WATER SAMPLE LOCATION
- ○ CANDIDATE EXCAVATION SITE

ROCKY MOUNTAIN ARSENAL SEWER INVESTIGATIONS

FIGURE 3.6 SAMPLING AND FIELD INVESTIGATION SITES, WEST SIDE OF SOUTH PLANTS SANITARY AND CONTAMINATED SEWERS

Drawn By: SMR	Date	Scale: 1"=100'	Exhibit No.
App'd. By: ALN	4-17-86	Date:	
Design By:	Date	Dwg. No.:	
App'd. By:			

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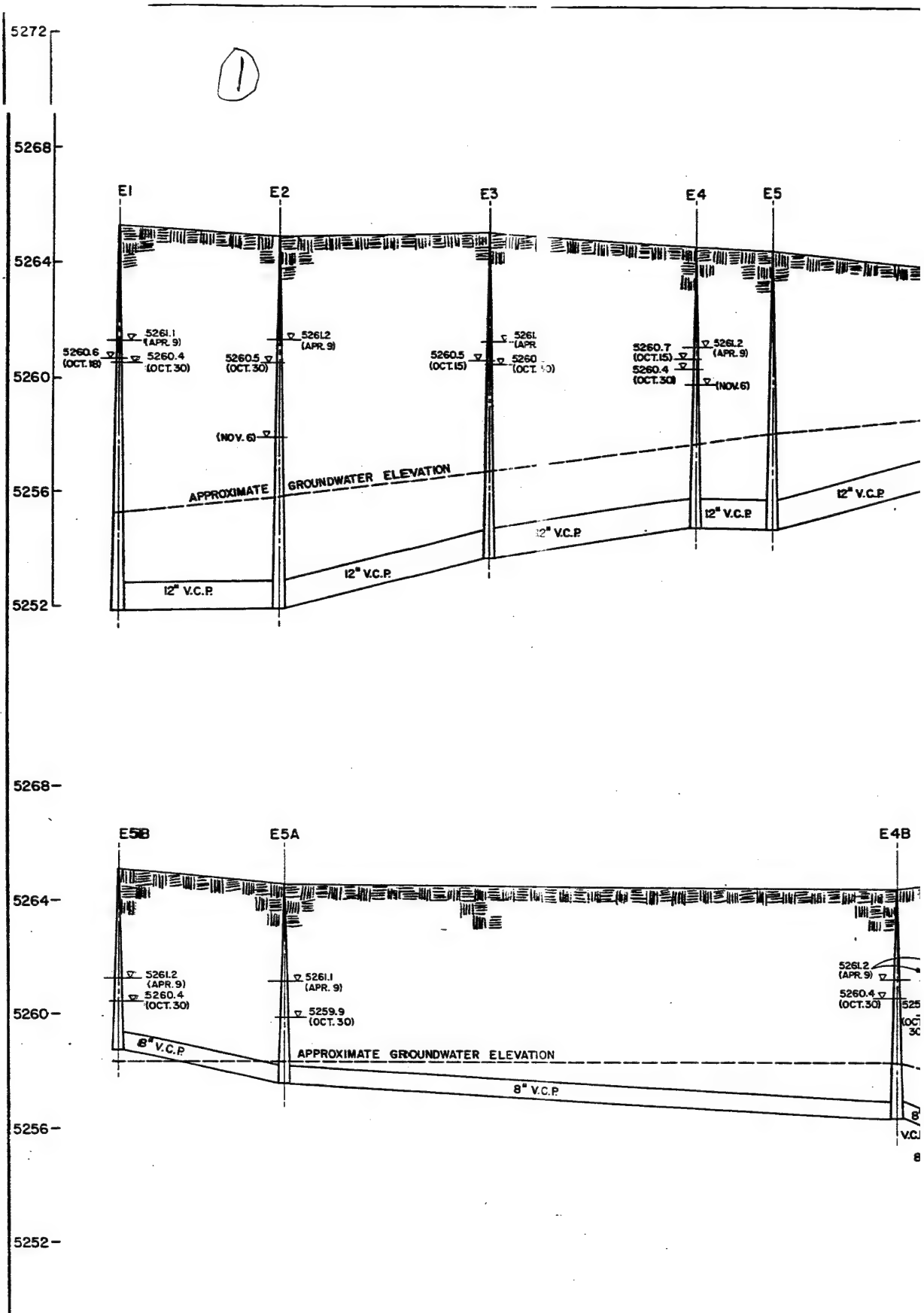
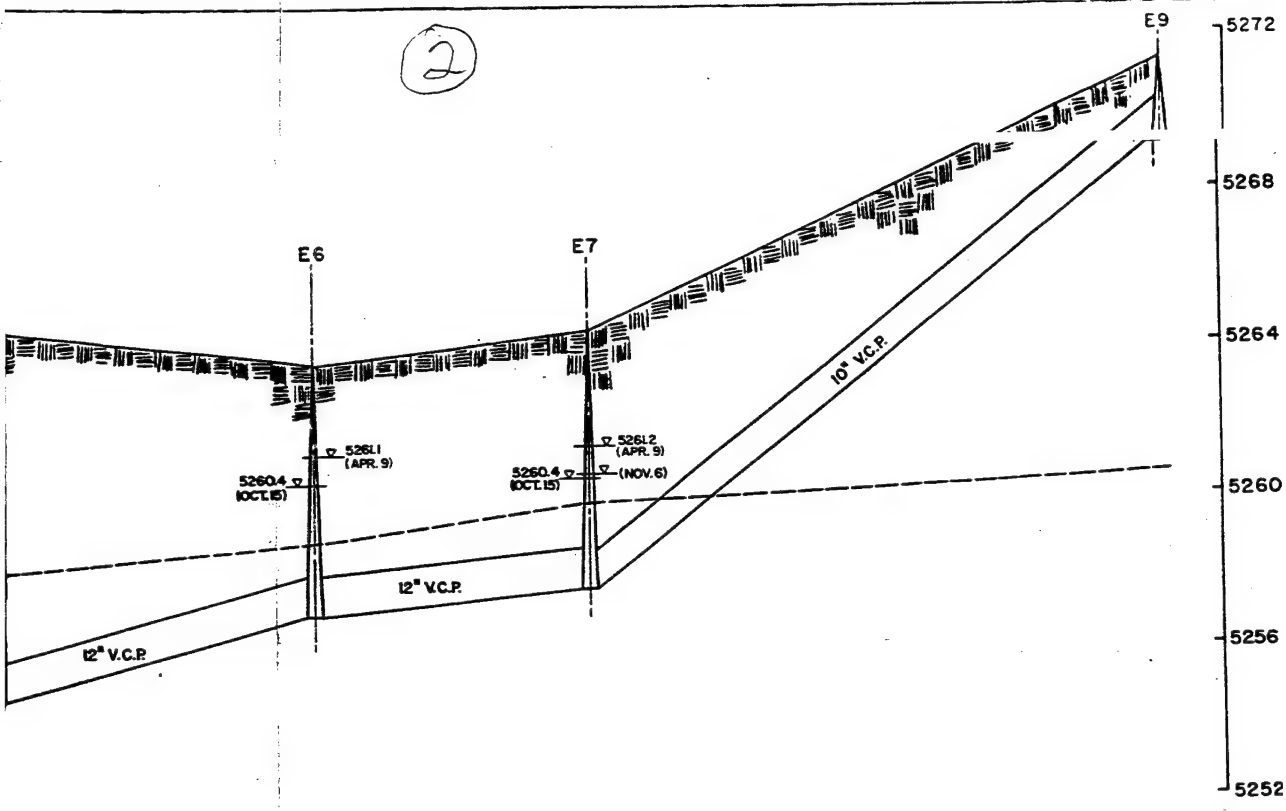
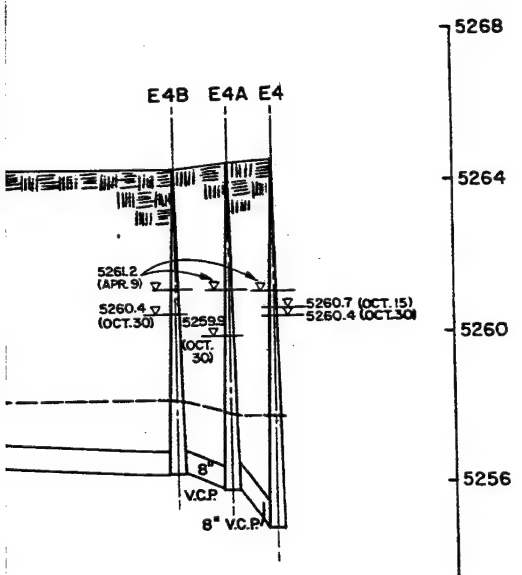
1700 Broadway, Suite 1600
Denver, Colorado 80290

CT098R01


5272
5268
5264
5260
5256
5252
E1
E2
E3
E4
E5
5261.1 (APR. 9)
5260.6 (OCT. 18)
5260.4 (OCT. 30)
5261.2 (APR. 9)
5260.5 (OCT. 30)
5261 (APR
5260.5 (OCT. 15)
5260 (OCT. 30)
5260.7 (OCT. 15)
5261.2 (APR. 9)
5260.4 (OCT. 30)
(NOV. 6)
(NOV. 6)
APPROXIMATE GROUNDWATER ELEVATION
12" V.C.P.
12" V.C.P.
12" V.C.P.
12" V.C.P.
12" V.C.P.
5268
5264
5260
5256
E5B
E5A
E4B
5261.2 (APR. 9)
5260.4 (OCT. 30)
5261.1 (APR. 9)
5259.9 (OCT. 30)
5261.2 (APR. 9)
5260.4 (OCT. 30)
8" V.C.P.
APPROXIMATE GROUNDWATER ELEVATION
8" V.C.P.
5256
5252





20 10 0

▽ (XXX)	STAND… DATE O…
	GROUN…

ROCKY …
SEWE…

FIG…
CONTAMI…

Drawn By:	
App'd. By:	ALN
Design By:	
App'd. By:	

MO…

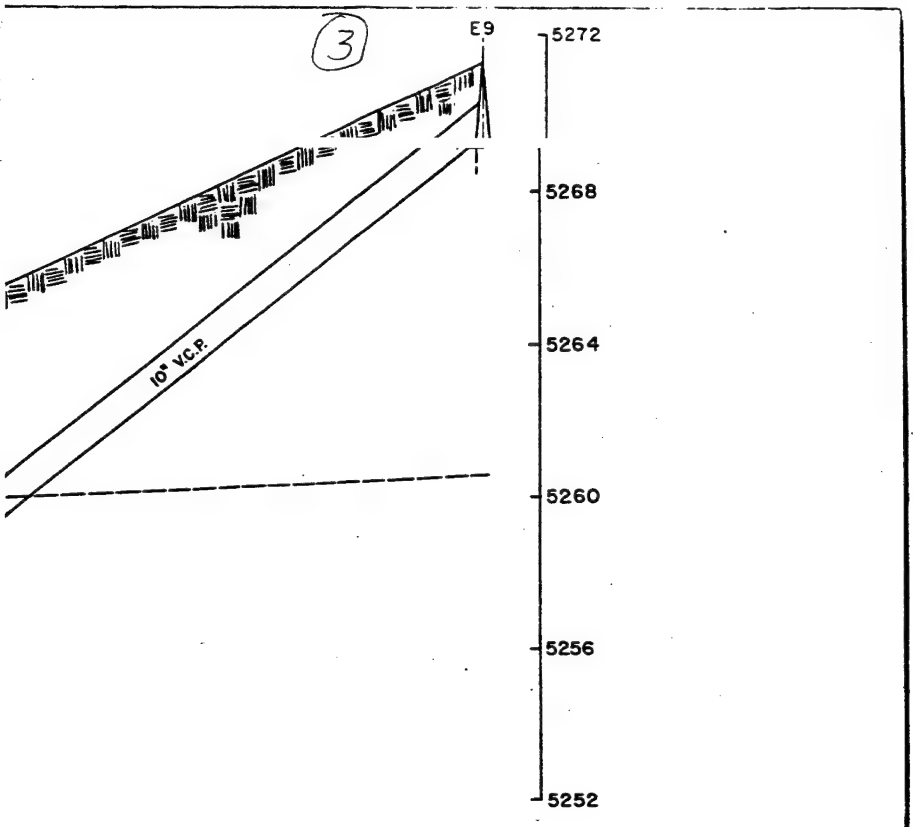
NOTES:

1. GROUNDWATER LEVELS BASED ON MAP PREPARED FROM SEPTEMBER, 1985 MEASUREMENTS OF SHELL CHEMICAL COMPANY WELL NETWORK.

2. MANHOLE DEPTHS AND ELEVATIONS DETERMINED FROM SCC DOCUMENTATION (APPENDIX A) AND SPOT CHECKED IN FIELD. PIPE LENGTHS BASED ON SCALING FROM SCC DRAWING YE-13367-1.

3. WATER LEVEL ELEVATIONS IN MANHOLES BASED ON FIELD MEASUREMENTS FROM TOP OF MANHOLE AND CALCULATED FROM MANHOLE RING ELEVATIONS FROM SCC DOCUMENTATION (APPENDIX A).

57



20 10 0 20 40 60

SCALE IN FEET

LEGEND

▽ (XXX)	STANDING WATER IN MANHOLE WITH DATE OF MEASUREMENT
———	GROUNDWATER LEVEL

ROCKY MOUNTAIN ARSENAL SEWER INVESTIGATIONS

FIGURE 3.5B CONTAMINATED SEWER PROFILES

Drawn By: SWR	Date	Scale:	
App'd. By: ALH	4-17-86	Date:	Exhibit No.
Design By:	Date		
App'd. By:		Dwg. No.:	

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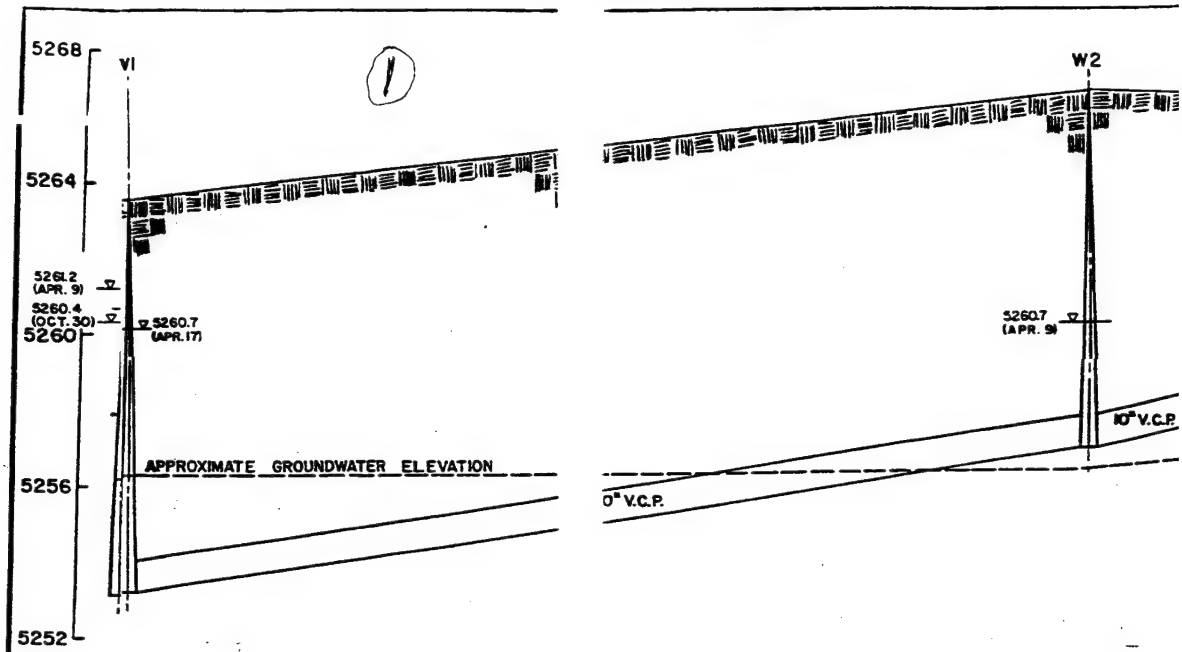
1700 Broadway, Suite 1600
Denver, Colorado 80290

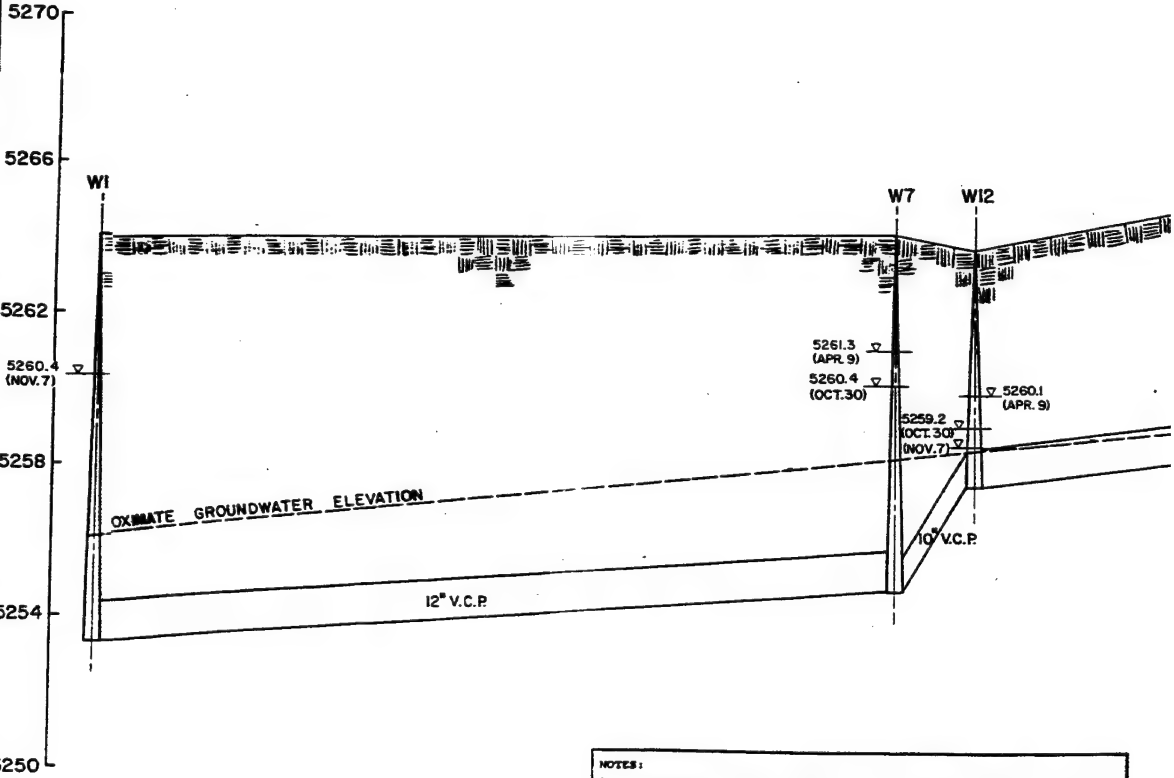
DWATER LEVELS BASED ON MAP PREPARED FROM SEPTEMBER, 1985 REMENTS OF SHELL CHEMICAL COMPANY WELL NETWORK.

LE DEPTHS AND ELEVATIONS DETERMINED FROM SCC DOCUMENTATION NDIX A) AND SPOT CHECKED IN FIELD. PIPE LENGTHS BASED ON NG FROM SCC DRAWING YE-13347-1.

LEVEL ELEVATIONS IN MANHOLES BASED ON FIELD MEASUREMENTS TOP OF MANHOLE AND CALCULATED FROM MANHOLE RING ELEVATIONS SCC DOCUMENTATION (APPENDIX A).

87393P51



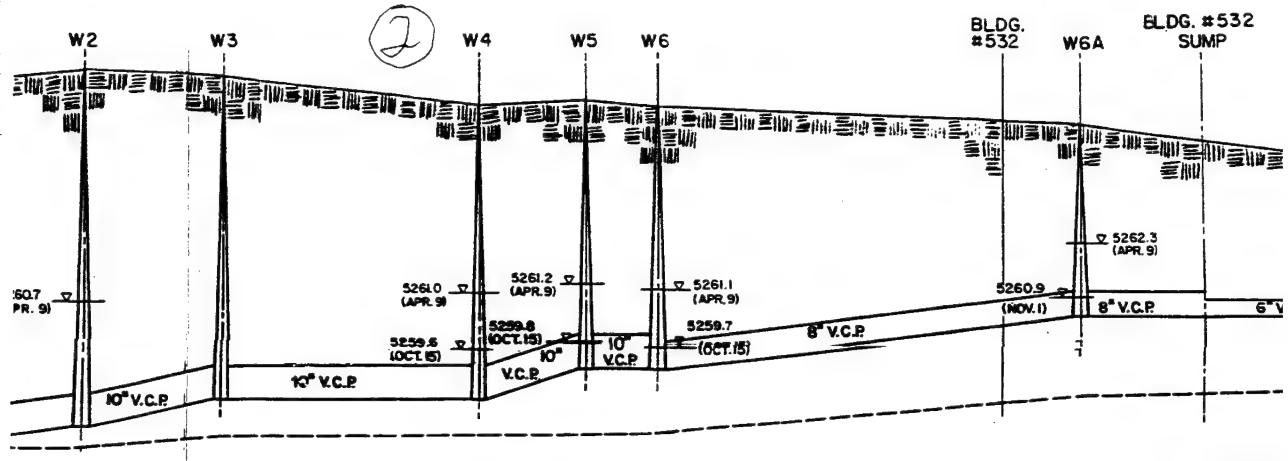


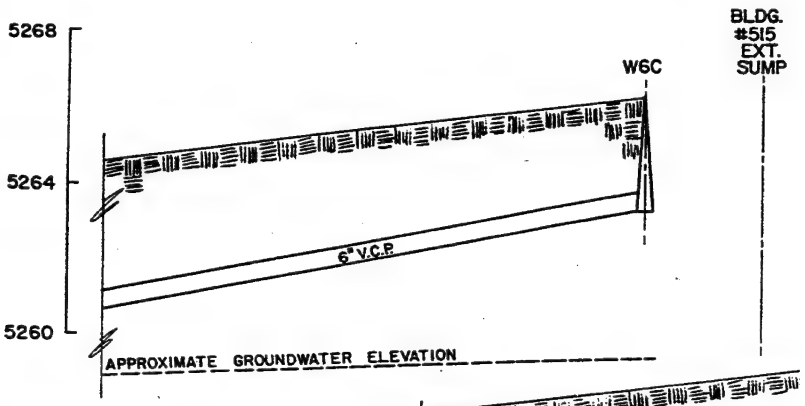
NOTES:

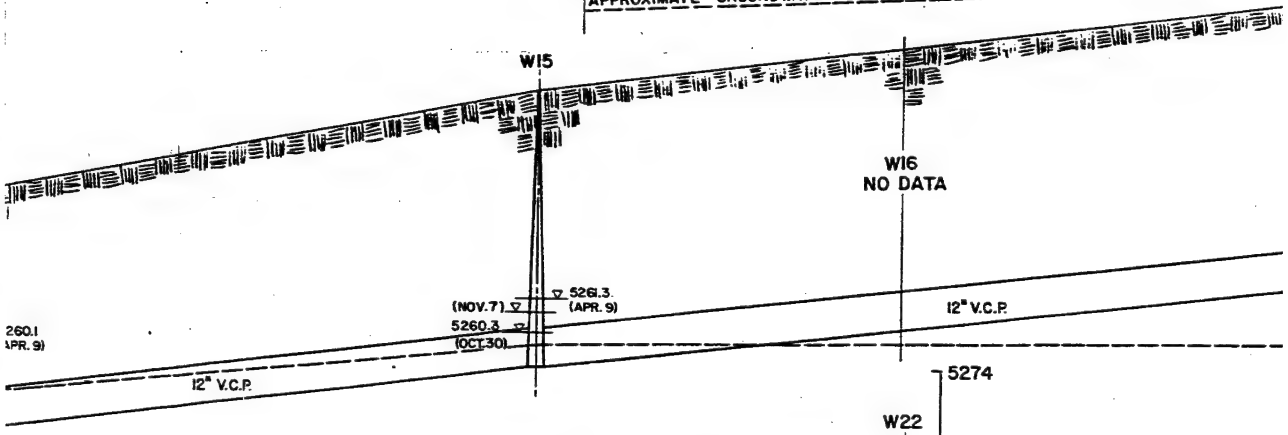
1. GROUNDWATER LEVELS BASED ON MAP PREPARED FROM SEPTEMBER, 1985 MEASUREMENTS OF SHELL CHEMICAL COMPANY WELL NETWORK.

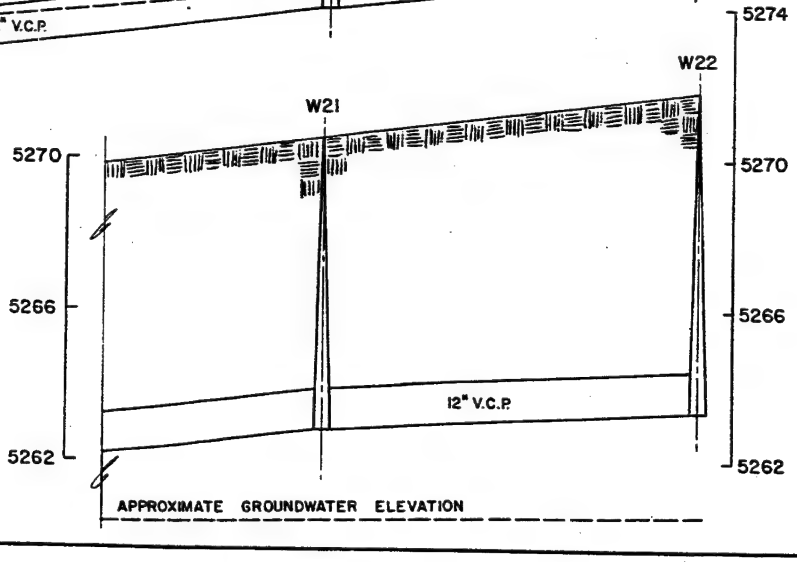
2. MANHOLE DEPTHS AND ELEVATIONS DETERMINED FROM SCC DOCUMENTATION (APPENDIX A) AND SPOT CHECKED IN FIELD. PIPE LENGTHS BASED ON SCALING FROM SCC DRAWING YE-13347-1.

3. WATER LEVEL ELEVATIONS IN MANHOLES BASED ON FIELD MEASUREMENTS FROM TOP OF MANHOLE AND CALCULATED FROM MANHOLE RING ELEVATIONS FROM SCC DOCUMENTATION. (APPENDIX A).









20 10 0 20

SCALE IN

LEGI

(XXX) STANDING WATER I
DATE OF MEASUREM

GROUNDWATER LE

ROCKY MOUN
SEWER INV

FIGURE
CONTAMINATED

Drawn By: SNR	Date	Sc
App'd. By: ALN	4-17-86	Da
Design By:	Date	
App'd. By:		Da

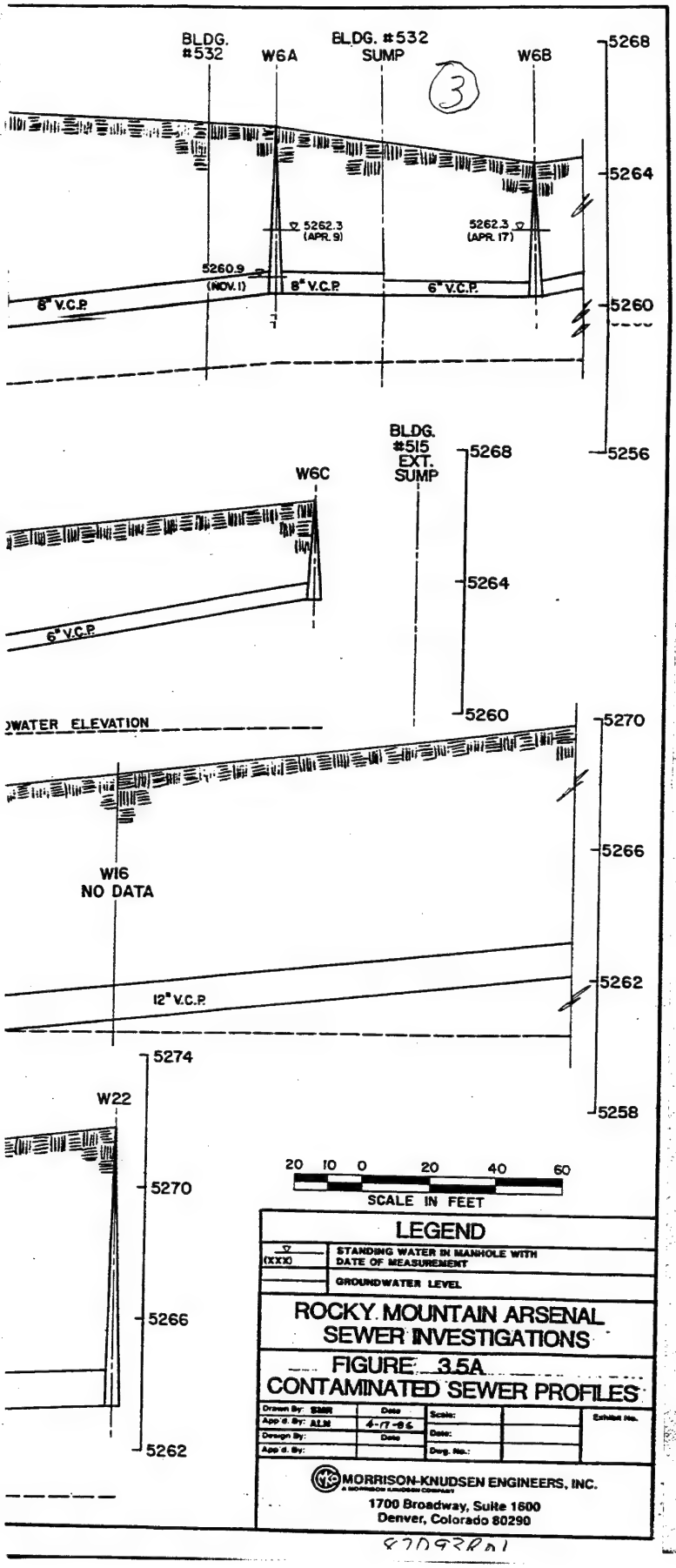
MORRISON-KNU

1700 Broad
Denver, C

EPTEMBER, 1985

DOCUMENTATION
NOTES BASED ON

REASUREMENTS
ING ELEVATIONS


BLDG. #532
W6A
BLDG. #532 SUMP
W6B
5268
5264
5260
5256
5262.3 (APR. 9)
5262.3 (APR. 17)
5260.9 (NOV. 1)
8" V.C.P.
8" V.C.P.
6" V.C.P.
BLDG. #515 EXT. SUMP
W6C
6" V.C.P.
WATER ELEVATION
5270
5266
5262
5258
W16
NO DATA
12" V.C.P.
5274
W22
5270
5266
5262
20 10 0 20 40 60
SCALE IN FEET
LEGEND
(XX)
STANDING WATER IN MANHOLE WITH DATE OF MEASUREMENT
GROUNDWATER LEVEL
ROCKY MOUNTAIN ARSENAL
SEWER INVESTIGATIONS
FIGURE 3.5A
CONTAMINATED SEWER PROFILES
Drawn By: SMR
App'd. By: ALM
Date 4-17-86
Design By:
App'd. By:
Scale:
Date:
Dwg. No.:
Exhibit No.
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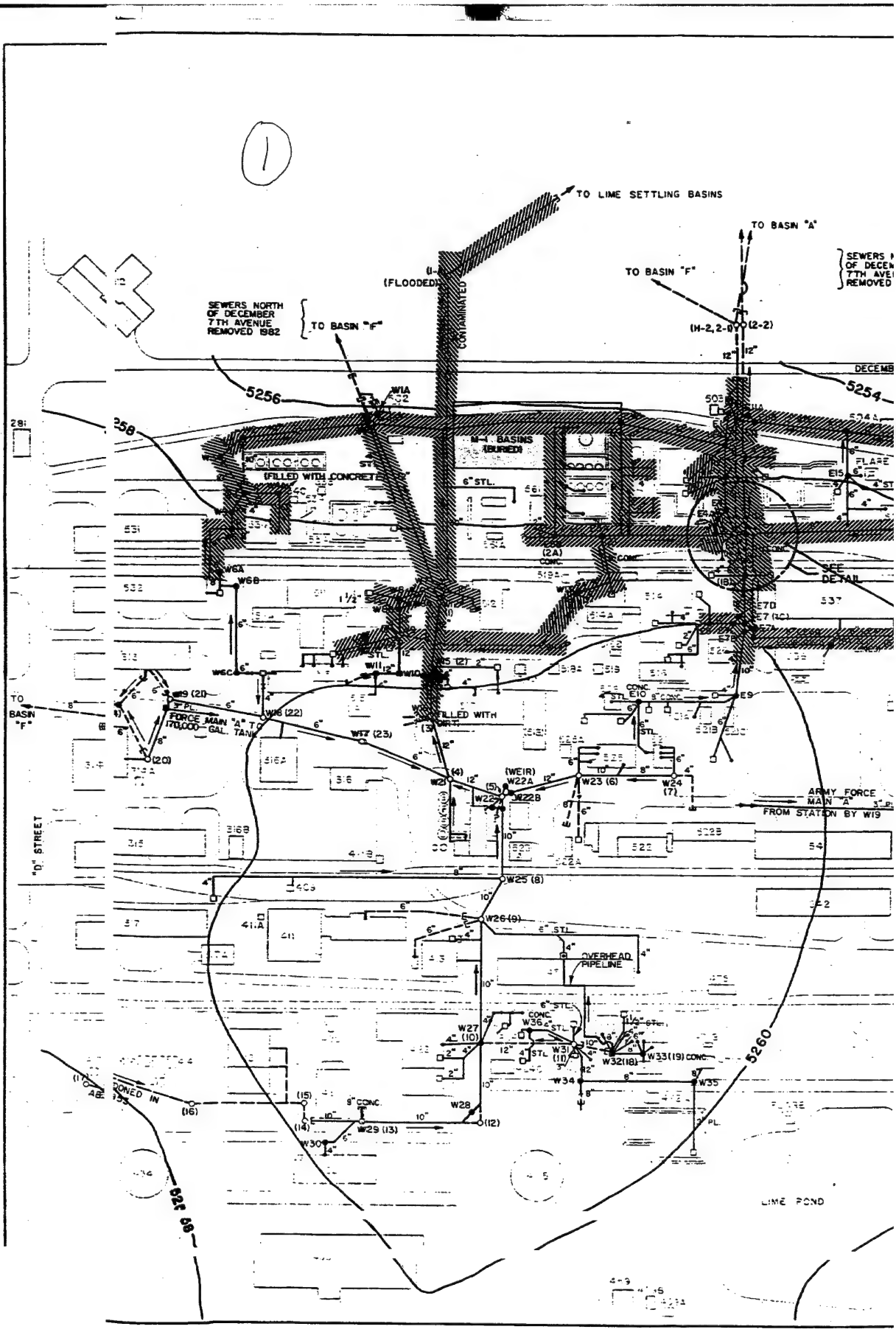
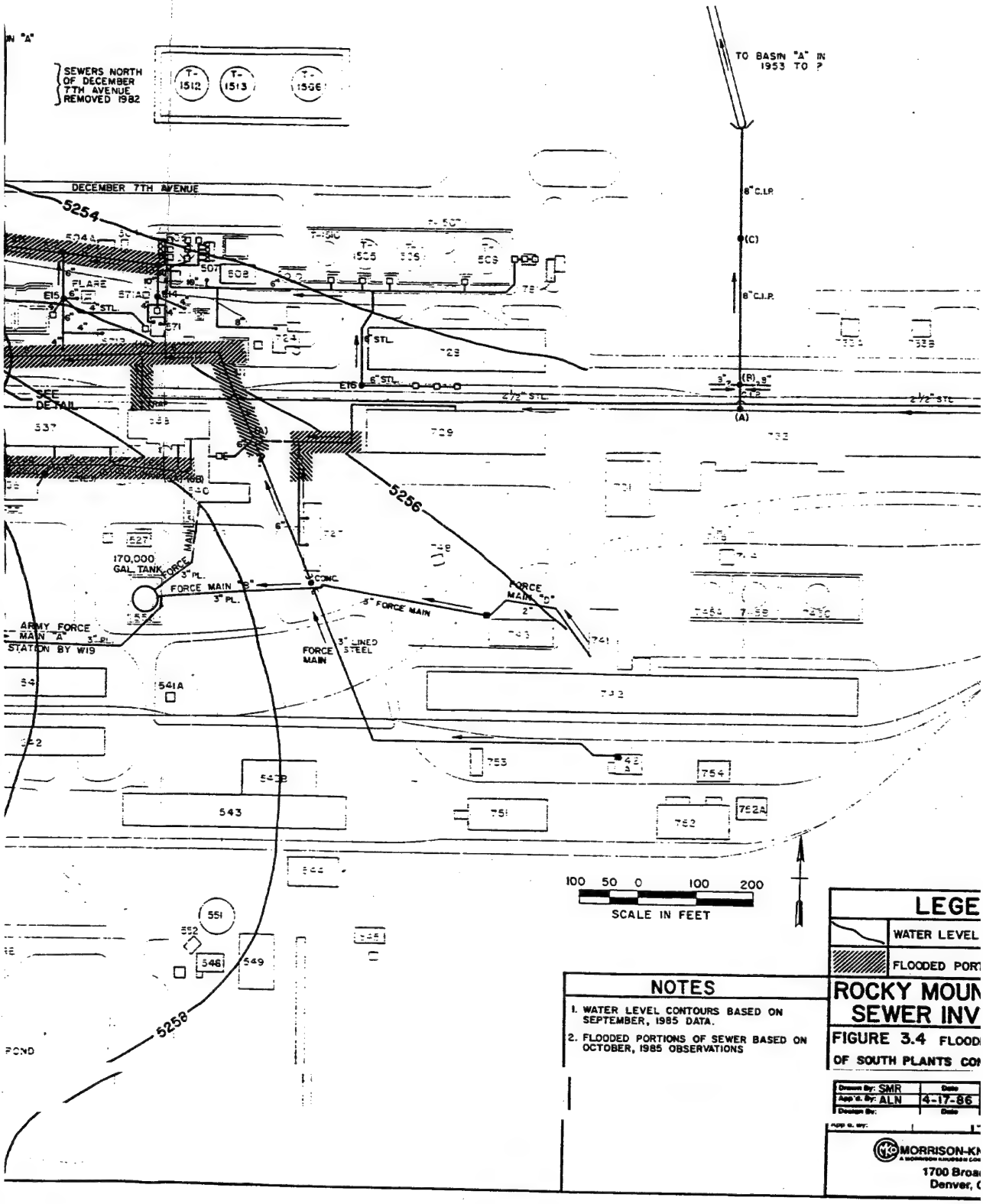
Denver, Colorado 80290

870928R01


TO LIME SETTLING BASINS
TO BASIN "A"
TO BASIN "F"
SEWERS NORTH OF DECEMBER 7TH AVENUE REMOVED 1982
TO BASIN "F"
SEWERS N OF DECEM 7TH AVE REMOVED
(FLOODED)
CONTAINED
(H-2,2-0)
(2-2)
DECEMB
5256
5254
5258
M-1 BASINS (BURIED)
(FILLED WITH CONCRETE)
6" STL.
FLARE
SEE DETAIL
W1A
W6A
W6B
W6C
W9 (20)
W8 (22)
W17 (23)
FORCE MAIN "A" TO 170,000 GAL. TANK
TO BASIN "F"
FILLED WITH
W2
W22A
W22B
W23 (6)
W24 (7)
ARMY FORCE MAIN "A" 3" PL
FROM STATION BY W19
"D" STREET
W25 (8)
W26 (9)
OVERHEAD PIPELINE
W27 (10)
W36
W31 (11)
W32 (18)
W33 (19) CONC.
W34
W35
W28
W29 (13)
W30
(12)
(14)
(15)
(16)
9" CONC.
5260
LIME POND

(2)



LEGE

WATER LEVEL

FLOODED PORT

NOTES

1. WATER LEVEL CONTOURS BASED ON SEPTEMBER, 1985 DATA.
2. FLOODED PORTIONS OF SEWER BASED ON OCTOBER, 1985 OBSERVATIONS

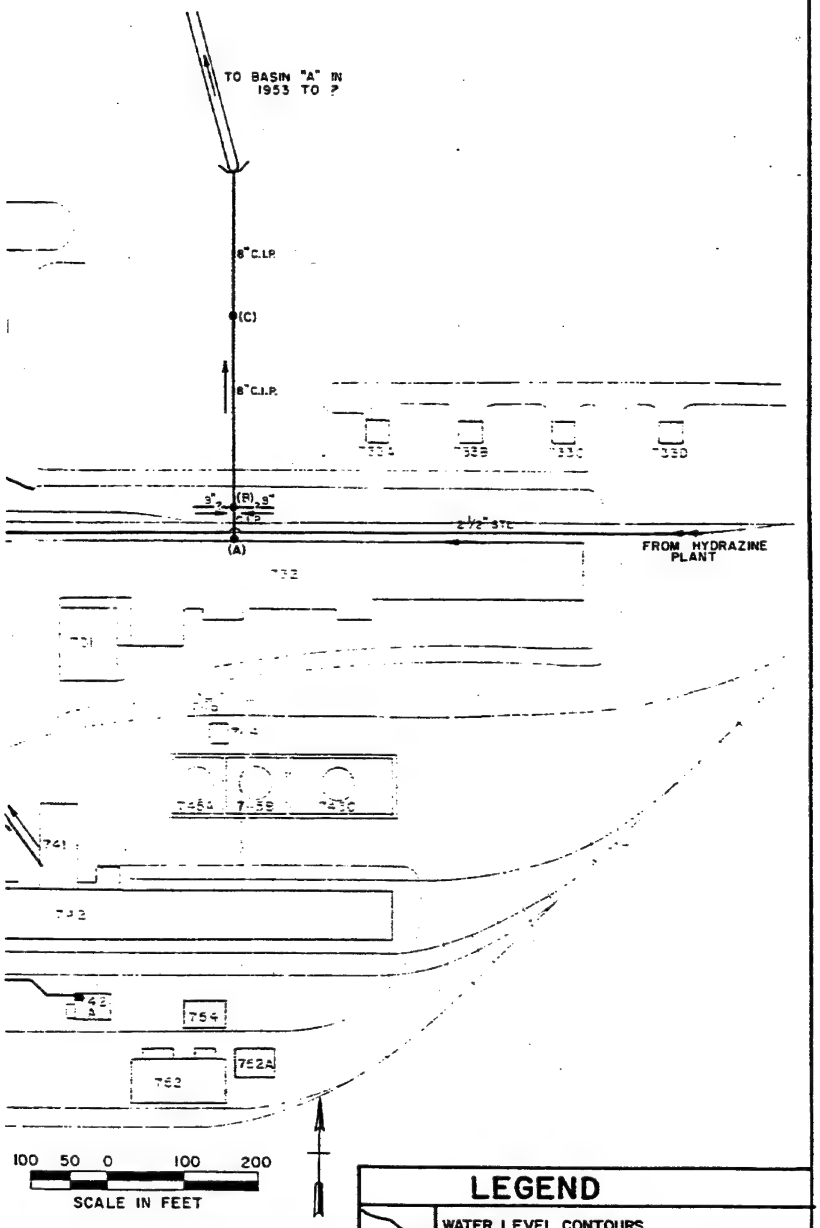
ROCKY MOUN SEWER INV

FIGURE 3.4 FLOOD OF SOUTH PLANTS CO

Drawn By: SMR	Date
App'd. By: ALN	4-17-86
Design By:	Date
App'd. by:	

MORRISON-K
1700 Broa
Denver, C

(3)



100 50 0 100 200

SCALE IN FEET

LEGEND

- WATER LEVEL CONTOURS
- FLOODED PORTIONS OF SEWER

NOTES

1. WATER LEVEL CONTOURS BASED ON SEPTEMBER, 1985 DATA.
2. FLOODED PORTIONS OF SEWER BASED ON OCTOBER, 1985 OBSERVATIONS

ROCKY MOUNTAIN ARSENAL SEWER INVESTIGATIONS

FIGURE 3.4 FLOODED PORTIONS OF EAST SIDE OF SOUTH PLANTS CONTAMINATED SEWER

Drawn By: SMR	Date	Scale: 1"=100'	Exhibit No.
App'd. By: ALN	4-17-86	Date: 4-15-86	
Division By:	Date		

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Denver, Colorado 80290

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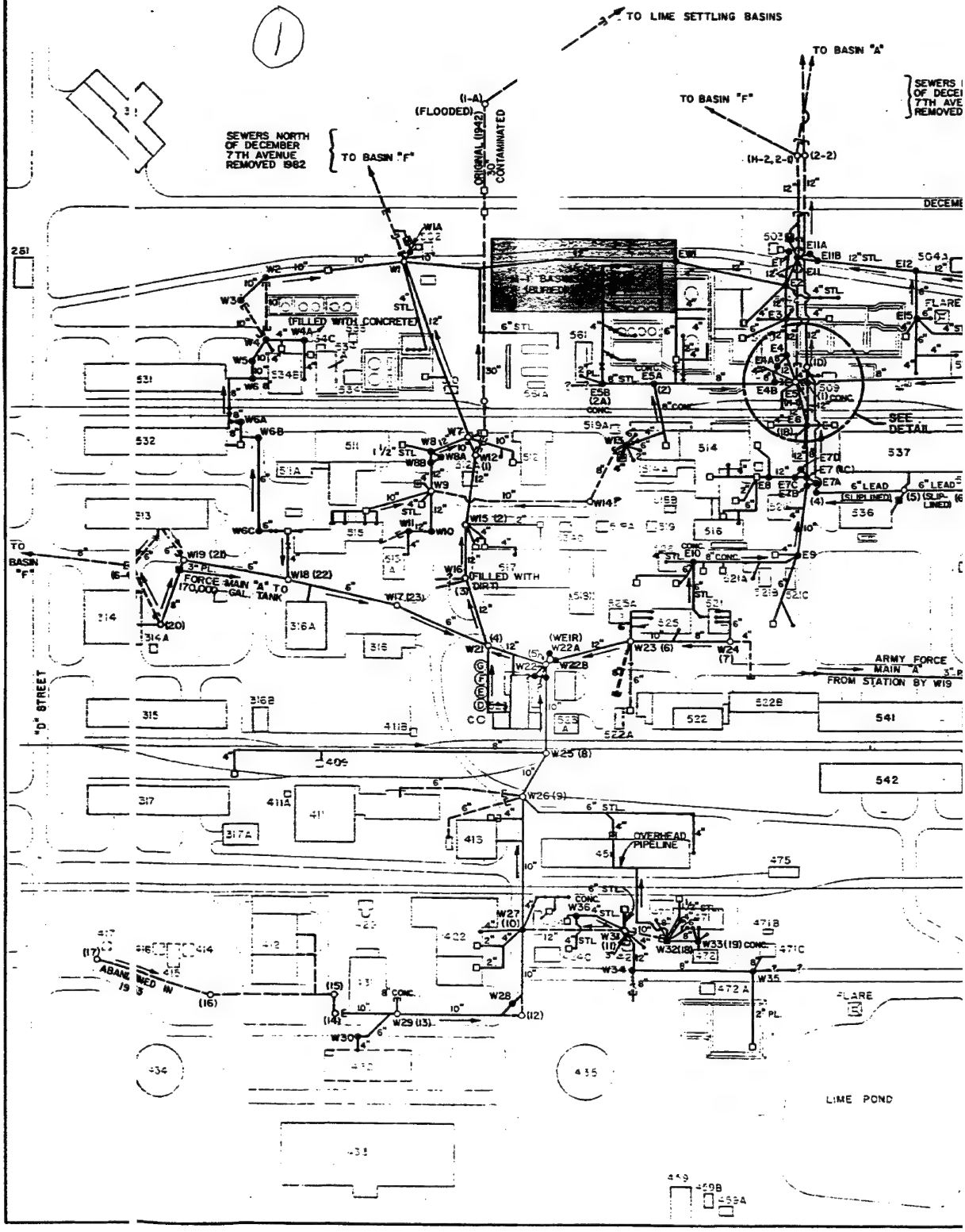
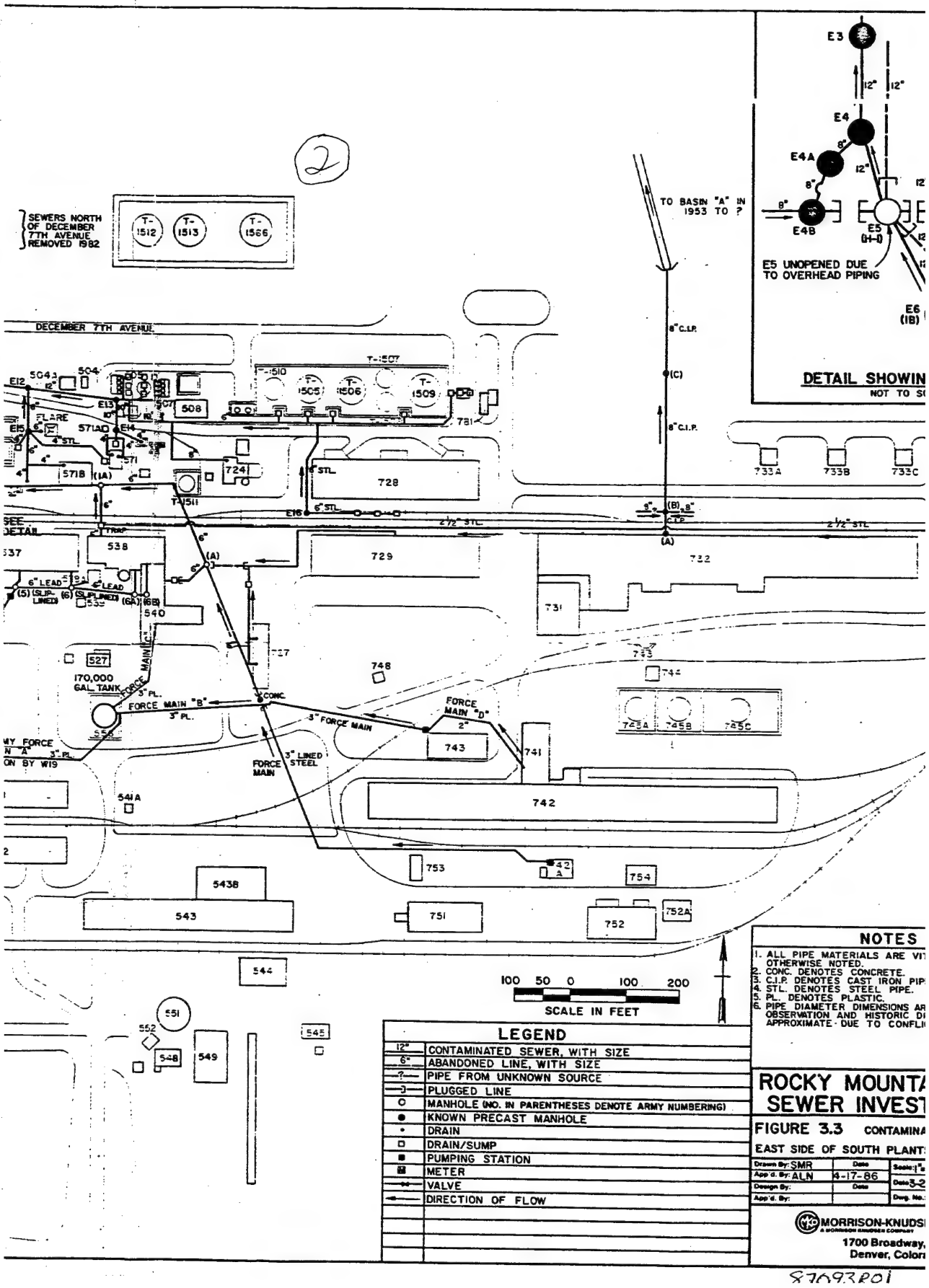

TO LIME SETTLING BASINS
TO BASIN "A"
TO BASIN "F"
SEWERS NORTH OF DECEMBER 7TH AVENUE REMOVED 1982
TO BASIN "F"
(I-A) (FLOODED)
ORIGINAL (1942) 30" CONTAMINATED
(I-2, 2-0)
(2-2)
SEWERS OF DECEMBER 7TH AVE REMOVED
DECEMBER
(FILLED WITH CONCRETE)
SEE DETAIL
6" LEAD (SLIP LINED)
6" LEAD (SLIP LINED)
FORCE MAIN "A" TO TANK 170,000 GAL.
(FILLED WITH DIRT)
(WEIR)
ARMY FORCE MAIN "A" FROM STATION BY W19
OVERHEAD PIPELINE
ABANDONED IN 19
LIME POND
"D" STREET
TO BASIN "F"
FLARE
FLARE



LEGEND

12"	CONTAMINATED SEWER, WITH SIZE
6"	ABANDONED LINE, WITH SIZE
?—	PIPE FROM UNKNOWN SOURCE
—J—	PLUGGED LINE
○	MANHOLE (NO. IN PARENTHESES DENOTE ARMY NUMBERING)
●	KNOWN PRECAST MANHOLE
•	DRAIN
□	DRAIN/SUMP
■	PUMPING STATION
▣	METER
⋈	VALVE
←	DIRECTION OF FLOW

NOTES

1. ALL PIPE MATERIALS ARE VI OTHERWISE NOTED.
2. CONC. DENOTES CONCRETE.
3. C.I.P. DENOTES CAST IRON PIP
4. STL. DENOTES STEEL PIPE.
5. PL. DENOTES PLASTIC.
6. PIPE DIAMETER DIMENSIONS AR OBSERVATION AND HISTORIC DI APPROXIMATE · DUE TO CONFLI

ROCKY MOUNTA SEWER INVEST

FIGURE 3.3 CONTAMINA

EAST SIDE OF SOUTH PLANT

Drawn By: SMR	Date	Scale: 1"
App'd. By: ALN	4-17-86	Date 3-2
Design By:	Date	
App'd. By:		Dwg. No.

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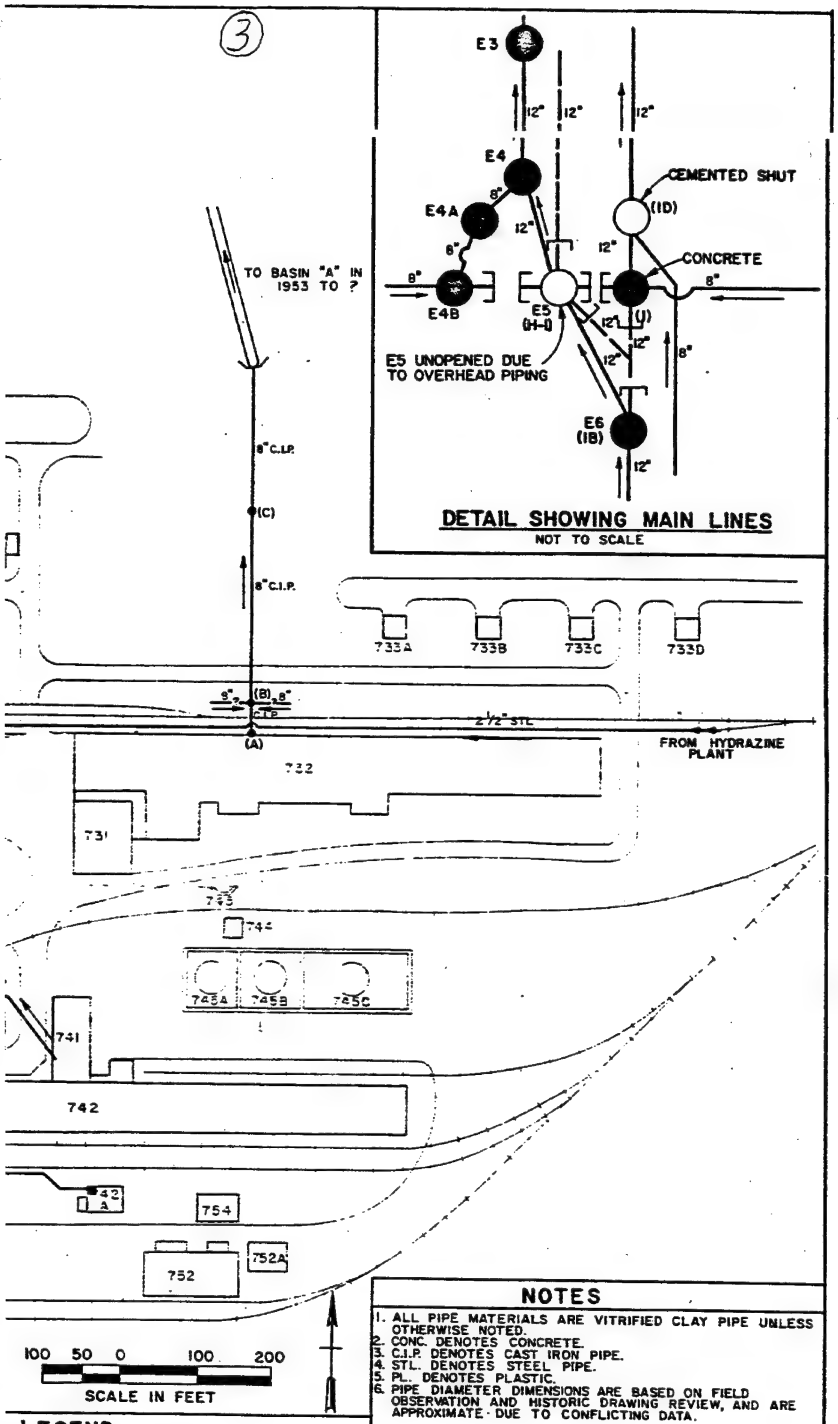
Denver, Color

87693R01



NOTES

1. ALL PIPE MATERIALS ARE VITRIFIED CLAY PIPE UNLESS OTHERWISE NOTED.
2. CONC. DENOTES CONCRETE.
3. C.I.P. DENOTES CAST IRON PIPE.
4. STL. DENOTES STEEL PIPE.
5. PL. DENOTES PLASTIC.
6. PIPE DIAMETER DIMENSIONS ARE BASED ON FIELD OBSERVATION AND HISTORIC DRAWING REVIEW, AND ARE APPROXIMATE DUE TO CONFLICTING DATA.

LEGEND

- ITED SEWER, WITH SIZE
- D LINE, WITH SIZE
- UNKNOWN SOURCE
- LINE
- NO. IN PARENTHESES DENOTE ARMY NUMBERING)
- ECAST MANHOLE
- IP
- TATION
- OF FLOW

ROCKY MOUNTAIN ARSENAL SEWER INVESTIGATIONS

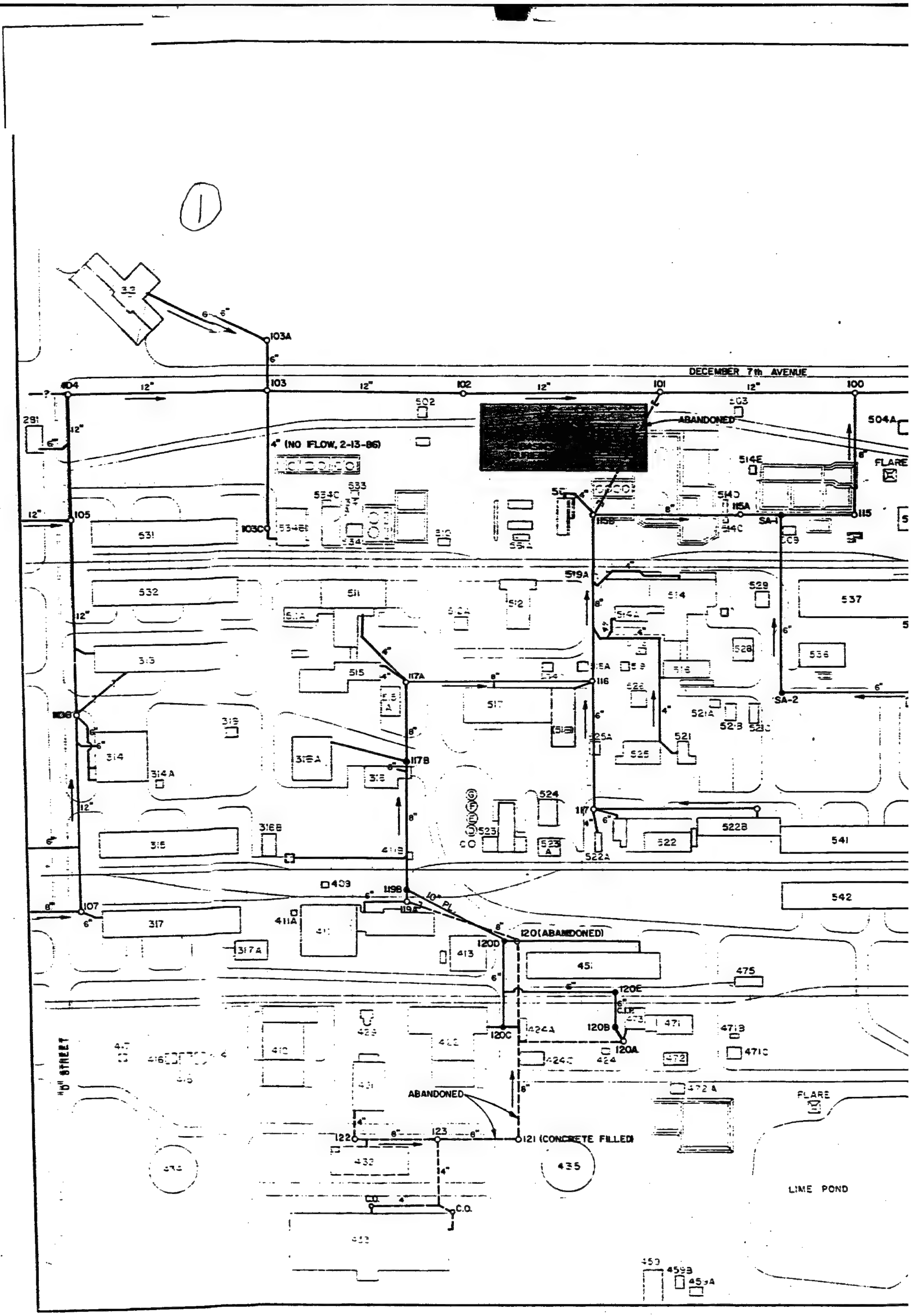
FIGURE 3.3 CONTAMINATED SEWER SYSTEM

EAST SIDE OF SOUTH PLANTS AREA

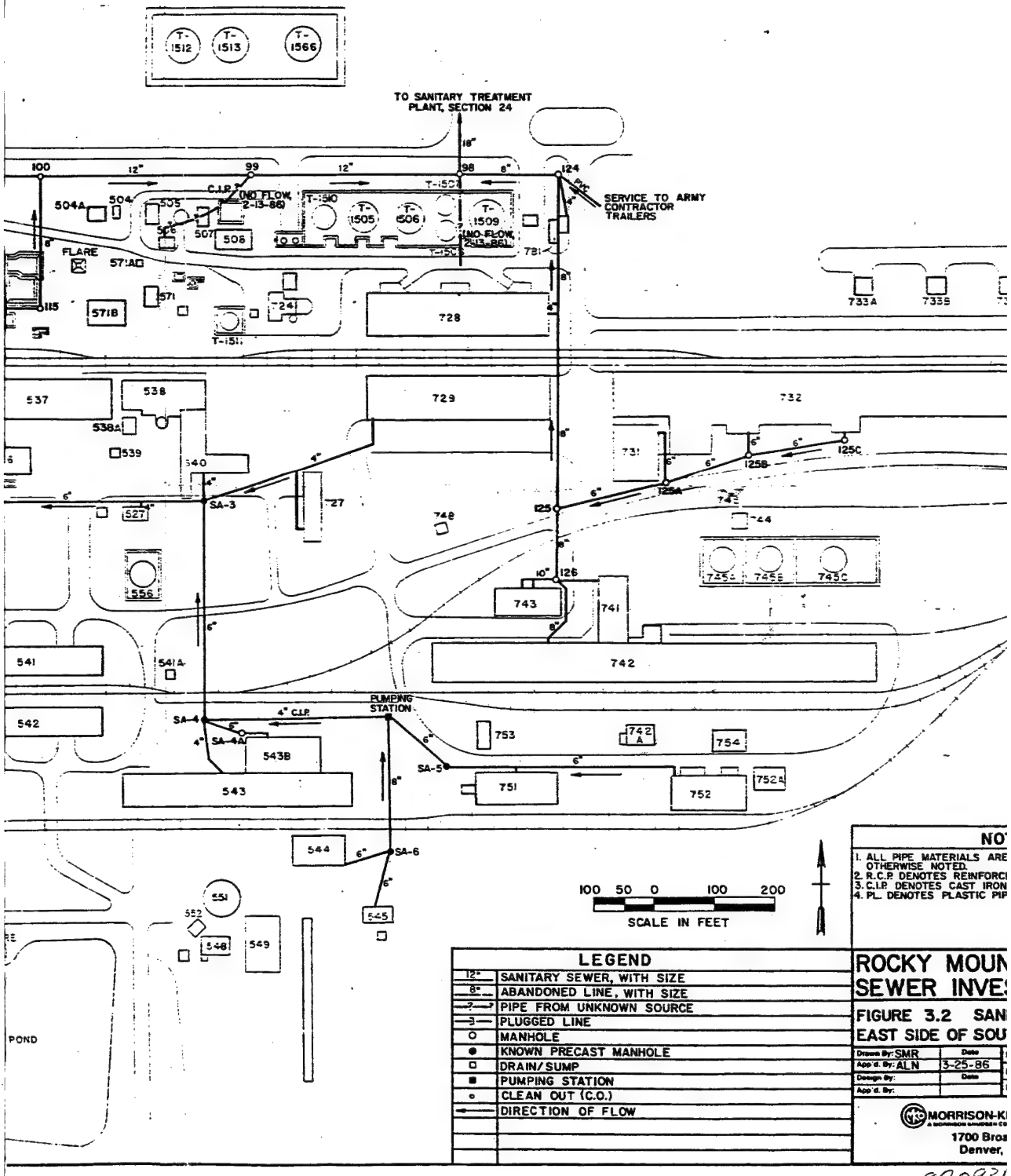
Drawn By: SMR	Date	Scale: 1"=100		Exhibit No.
App'd. By: ALN	4-17-86	Date 3-20-86		
Design By:	Date	Dwg. No.:		
App'd. By:				

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY
1700 Broadway, Suite 1600
Denver, Colorado 80290

87A9380 01


DECEMBER 7th AVENUE
"D" STREET
103A
104
103
102
101
100
ABANDONED
4" (NO FLOW, 2-13-86)
504A
FLARE
105
103C
115B
115A
115
SA-1
SA-2
519A
117A
116
117B
117
119B
119A
10" PL
120 (ABANDONED)
120D
120E
120C
120B
120A
C.I.P.
ABANDONED
122
123
121 (CONCRETE FILLED)
C.O.
LIME POND
FLARE
531
532
537
536
517
515
511
512
514
525
522
522B
541
542
317
317A
316
314
314A
318A
411
411A
413
451
475
471
472
471B
471C
472A
424A
424C
424
432
435
459
459B
459A
291
522A
524
523
521
521A
529
528
514E
514D
514C
409
318B

(2)



LEGEND

12"	SANITARY SEWER, WITH SIZE
8"	ABANDONED LINE, WITH SIZE
??	PIPE FROM UNKNOWN SOURCE
	PLUGGED LINE
○	MANHOLE
●	KNOWN PRECAST MANHOLE
□	DRAIN/SUMP
■	PUMPING STATION
○	CLEAN OUT (C.O.)
	DIRECTION OF FLOW

NO

1. ALL PIPE MATERIALS ARE OTHERWISE NOTED.
2. R.C.P. DENOTES REINFORCI
3. C.I.P. DENOTES CAST IRON
4. P.L. DENOTES PLASTIC PIP

ROCKY MOUN
SEWER INVES

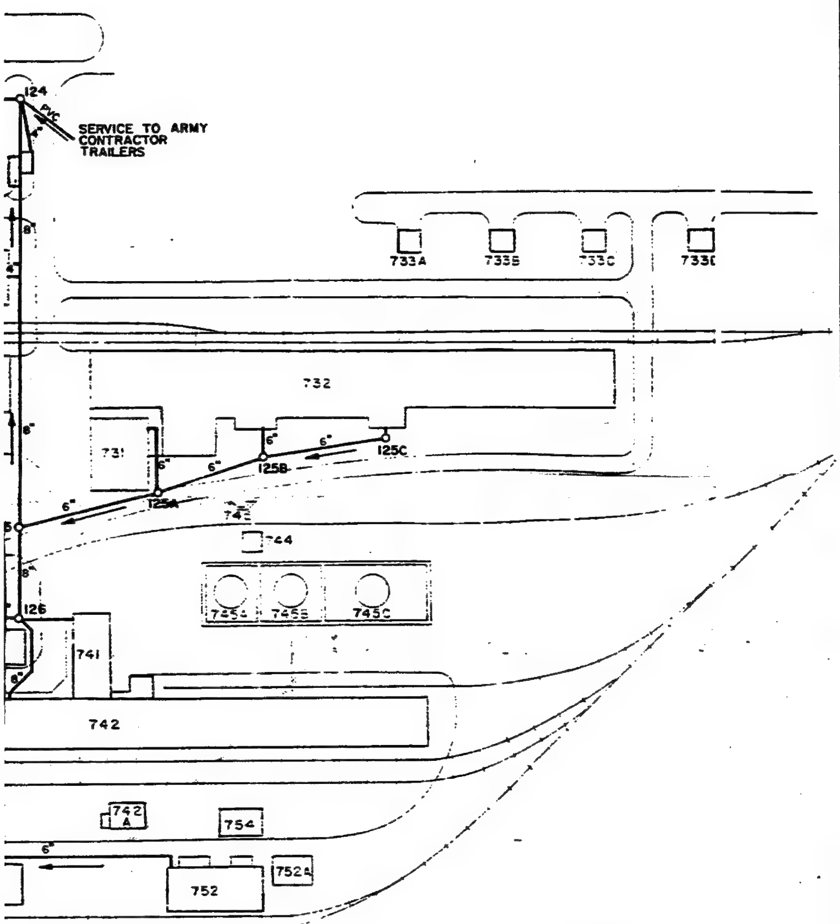
FIGURE 3.2 SAN
EAST SIDE OF SOU

Drawn By: SMR	Date
App'd. By: ALN	3-25-86
Design By:	Date
App'd. By:	

MORRISON-K
1700 Bros
Denver,

870936

③



NOTES

1. ALL PIPE MATERIALS ARE VITRIFIED CLAY PIPE UNLESS OTHERWISE NOTED.
2. R.C.P. DENOTES REINFORCED CONCRETE PIP
3. C.I.P. DENOTES CAST IRON PIPE.
4. PL. DENOTES PLASTIC PIPE.

100 50 0 100 200

SCALE IN FEET

LEGEND

RY SEWER, WITH SIZE
ONED LINE, WITH SIZE
ROM UNKNOWN SOURCE
ED LINE
LE
PRECAST MANHOLE
SUMP
IG STATION
OUT (C.O.)
TION OF FLOW

ROCKY MOUNTAIN ARSENAL SEWER INVESTIGATIONS

FIGURE 3.2 SANITARY SEWER SYSTEM EAST SIDE OF SOUTH PLANTS AREA

Drawn By: SMR	Date	Scale: 1"=100'	
App'd. By: ALN	3-25-86	Date: 3-19-86	
Design By:	Date		
App'd. By:		Dwg. No.:	

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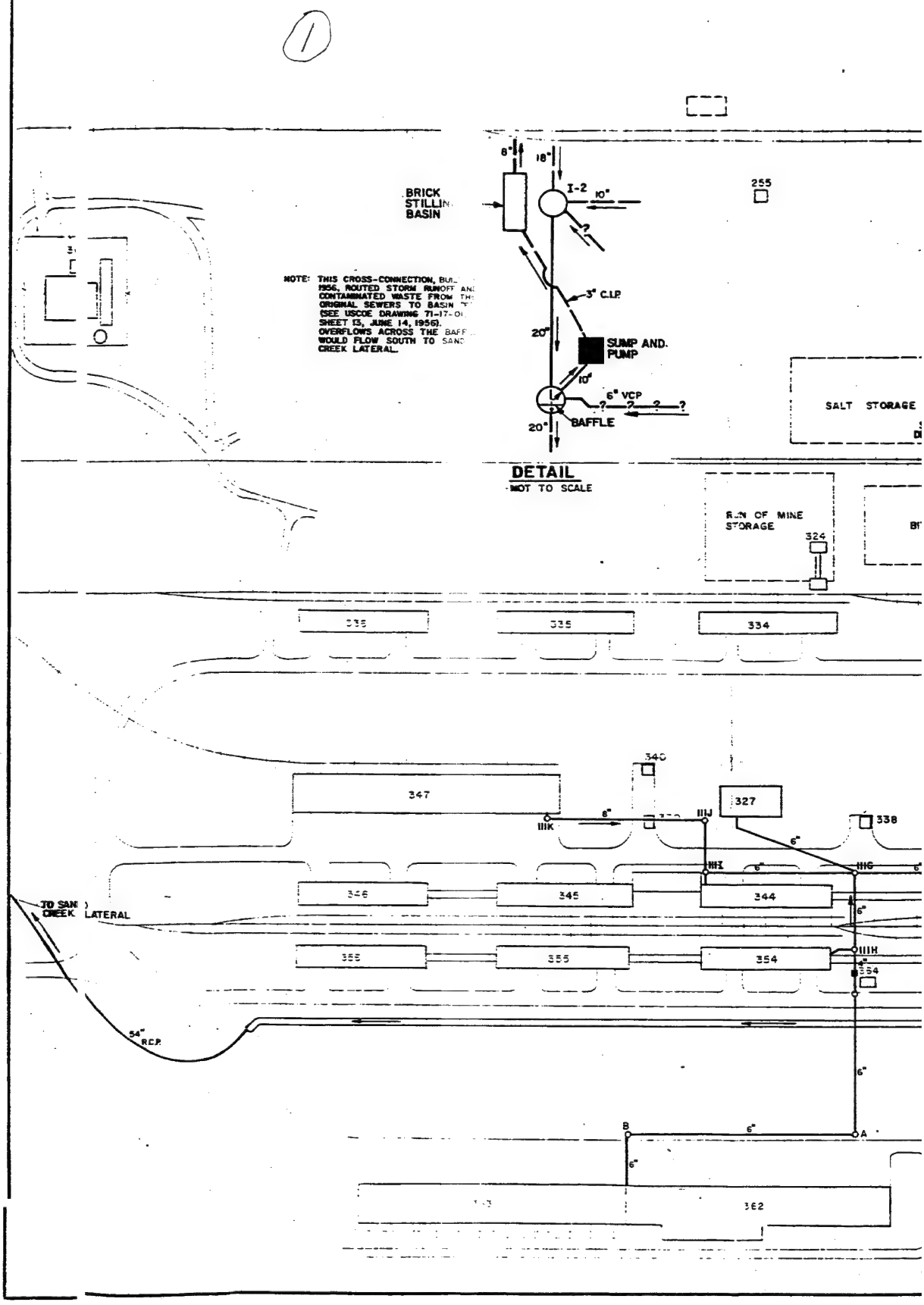
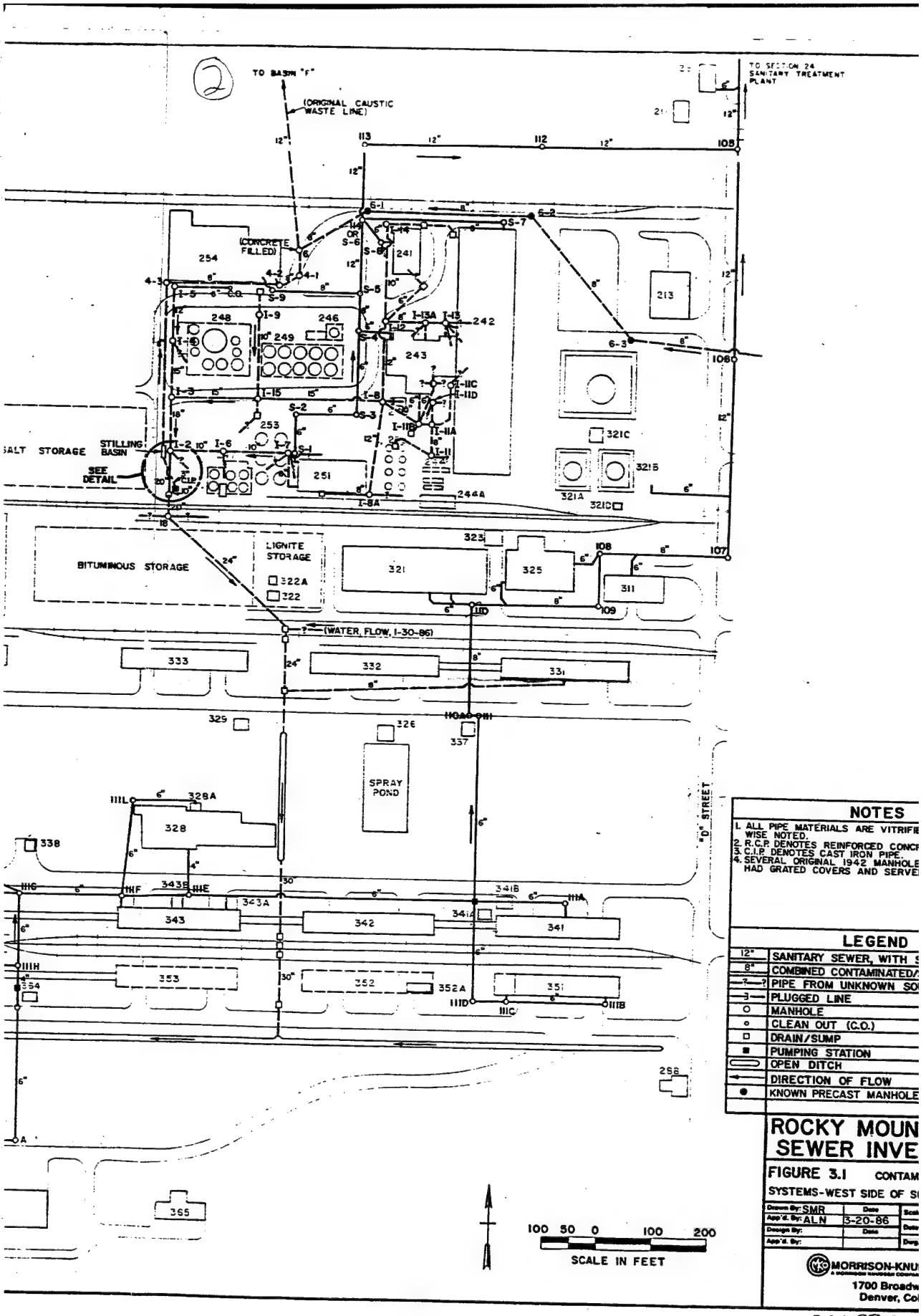
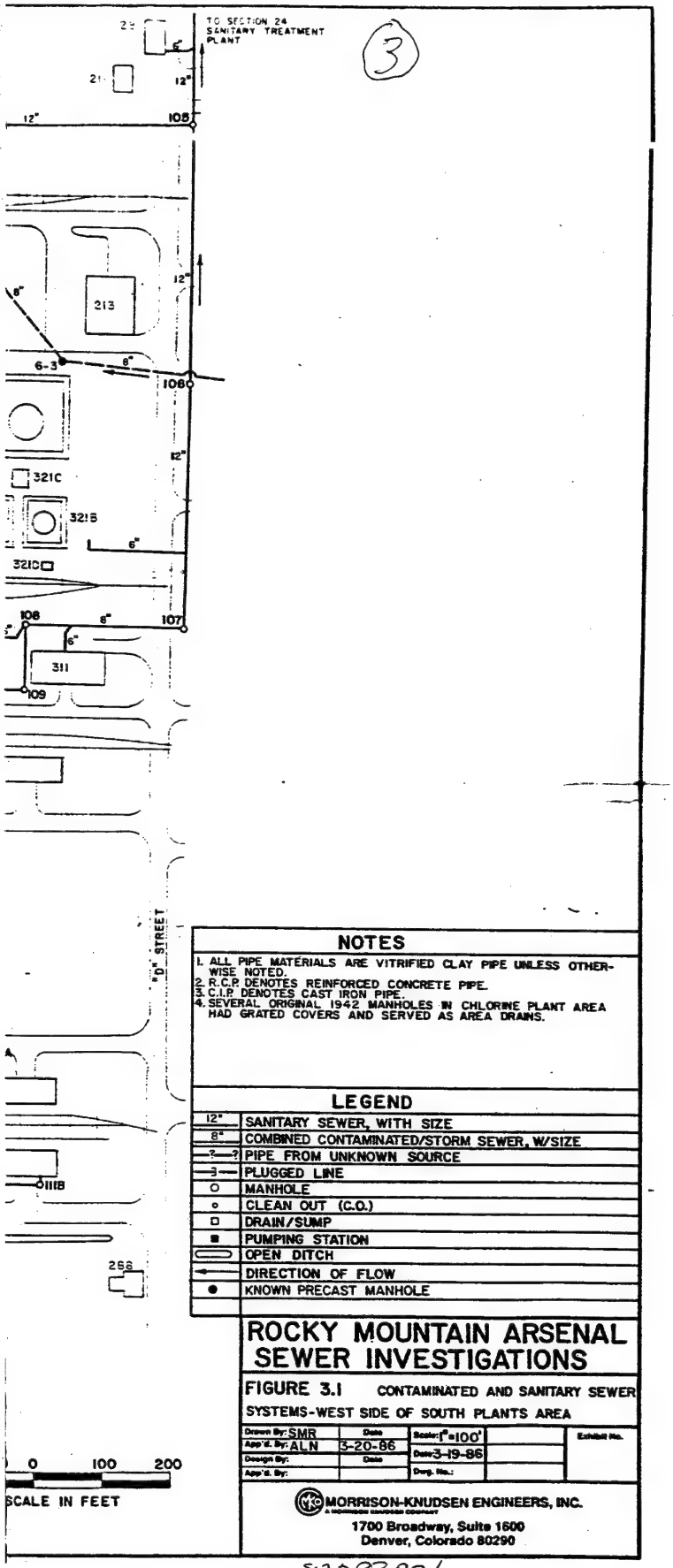
Denver, Colorado 80290

87093R01


BRICK STILLING BASIN
NOTE: THIS CROSS-CONNECTION, BUI... 1956, ROUTED STORM RUNOFF AN... CONTAMINATED WASTE FROM TH... ORIGINAL SEWERS TO BASIN ... (SEE USCOE DRAWING 71-17-01 SHEET 13, JUNE 14, 1956). OVERFLOWS ACROSS THE BAFF... WOULD FLOW SOUTH TO SAND CREEK LATERAL.
8"
18"
I-2
10"
?
3" C.I.P.
20"
SUMP AND PUMP
10"
6" VCP
? ? ? ?
20"
BAFFLE
DETAIL
NOT TO SCALE
255
SALT STORAGE
RUN OF MINE STORAGE
324
335
335
334
340
347
327
338
IIIK
IIIJ
IIII
IIIG
6"
346
345
344
355
355
354
354
TO SAND CREEK LATERAL
54" R.C.P.
B
A
362


(2)
TO BASIN "F"
(ORIGINAL CAUSTIC WASTE LINE)
TO SECTION 24 SANITARY TREATMENT PLANT
(CONCRETE FILLED)
STILLING BASIN
SEE DETAIL
SALT STORAGE
BITUMINOUS STORAGE
LIGNITE STORAGE
(WATER FLOW, I-30-86)
SPRAY POND
D STREET
254
248
246
249
253
251
241
242
243
244A
213
321C
321B
321A
321D
323
321
325
311
322A
322
333
332
331
329
326
337
328A
328
338
343B
343A
343
342
341B
341A
341
353
352
352A
351
354
356
365
NOTES
1. ALL PIPE MATERIALS ARE VITRIFI
WISE NOTED.
2. R.C.P. DENOTES REINFORCED CONCI
3. C.I.P. DENOTES CAST IRON PIPE.
4. SEVERAL ORIGINAL 1942 MANHOLE
HAD GRATED COVERS AND SERVE
LEGEND
12" SANITARY SEWER, WITH S
8" COMBINED CONTAMINATED/
? ? PIPE FROM UNKNOWN SO
PLUGGED LINE
MANHOLE
CLEAN OUT (C.O.)
DRAIN/SUMP
PUMPING STATION
OPEN DITCH
DIRECTION OF FLOW
KNOWN PRECAST MANHOLE
ROCKY MOUN
SEWER INVE
FIGURE 3.1 CONTAM
SYSTEMS-WEST SIDE OF S
Drawn By: SMR
App'd. By: ALN
3-20-86
Design By:
App'd. By:
MORRISON-KNU
1700 Broadw
Denver, Co
100 50 0 100 200
SCALE IN FEET

81093R01



NOTES

1. ALL PIPE MATERIALS ARE VITRIFIED CLAY PIPE UNLESS OTHERWISE NOTED.
2. R.C.P. DENOTES REINFORCED CONCRETE PIPE.
3. C.I.P. DENOTES CAST IRON PIPE.
4. SEVERAL ORIGINAL 1942 MANHOLES IN CHLORINE PLANT AREA HAD GRATED COVERS AND SERVED AS AREA DRAINS.

LEGEND

12"	SANITARY SEWER, WITH SIZE
8"	COMBINED CONTAMINATED/STORM SEWER, W/SIZE
?—?	PIPE FROM UNKNOWN SOURCE
—3—	PLUGGED LINE
○	MANHOLE
○	CLEAN OUT (C.O.)
□	DRAIN/SUMP
■	PUMPING STATION
⬭	OPEN DITCH
←	DIRECTION OF FLOW
●	KNOWN PRECAST MANHOLE

ROCKY MOUNTAIN ARSENAL SEWER INVESTIGATIONS

FIGURE 3.1 CONTAMINATED AND SANITARY SEWER SYSTEMS-WEST SIDE OF SOUTH PLANTS AREA

Drawn By: SMR	Date	Scale: 1"=100'		Exhibit No.
App'd. By: ALN	3-20-86	Date: 3-19-86		
Design By:	Date	Dwg. No.:		
App'd. By:				

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY
1700 Broadway, Suite 1600
Denver, Colorado 80290

87093R01

APPENDIX A

SHELL CHEMICAL COMPANY CONTAMINATED SEWER SURVEY, MAY, 1979

CONTAMINATED SEWER SURVEY (Sheet 1)

EAST SIDE

MANHOLE NO.	RING ELEVATION	INVERT ELEVATION	
E-1	5265.25	5252.08	B-A
E-3	5265.09	5253.76	E
E-4	5264.66	5254.83	A
E-4B	5264.28	5256.28	A-B
E-5	5264.47	5254.64	A-D
E-5A	5264.48	5257.48	A
E-5B	5265.03	5258.70	B
E-6	5263.47	5256.89	A-E
E-7	5264.34	5257.59	C
E-8	5271.51		
E-9	5271.33	5269.08	A-D
E-10	5273.37	5271.20	A-E
E-12	5266.16	5258.33	A-B-C
E-13	5266.22	5258.89	A-C
E-14			
E-15	5266.06	5261.23	E
E-16	5266.23	5262.15	A-B

WEST SIDE

W-1	5264.09	5253.34	A-B
W-2	5266.88	5257.38	A-B-C
W-3	5266.78	5258.28	A-B
W-5	5266.08	5259.08	A-B
W-7	5264.37	5254.87	B-C
W-8	5263.97	5255.55	A-B
W-12	5263.91	5257.74	B
W-15	5266.78	5259.53	A

TITLE

JOB NO.

SHELL CHEMICAL COMPANY
DENVER PLANT

DRAWN BY LEL

DATE May 25,1979

SCALE UE-13776 Sht. 1

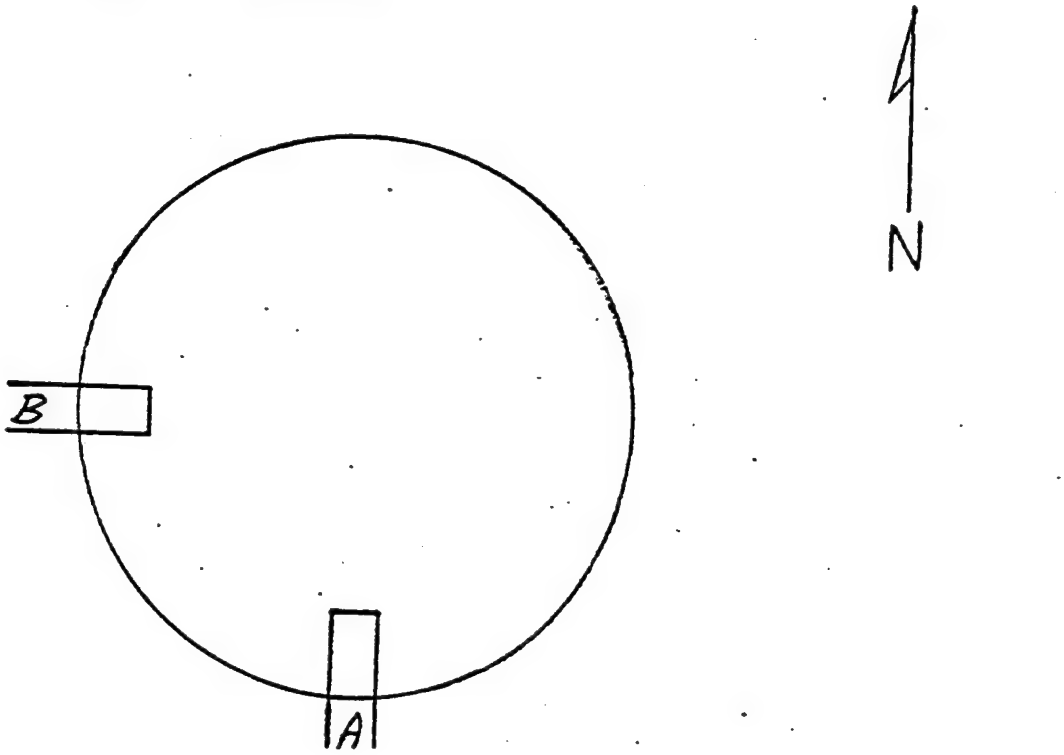
WEST SIDE CONT'D

W-16	5268.25		
W-17			
W-18	5268.78	5265.95	A-B
W-21	5270.59	5262.84	A-B
W-22	5271.83	5263.33	A-B-D
W-23	5271.03	5267.45	A-B-C
W-25	5271.38	5264.38	A-B
W-26	5273.28	5264.78	B-E
W-27	5271.39	5265.39	A-D-F
W-28	5271.71	5265.21	A-B
W-29	5270.71	5266.46	A-C
W-30	5271.51	5267.75	A-B
W-31	5272.74	5265.49	C
W-32	5272.06	5267.06	A
W-33	5271.53	5268.20	A

Manhole Number E 1

Approximate Depth* 13'-2"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 560'-10" W 1130'-4 7/8"

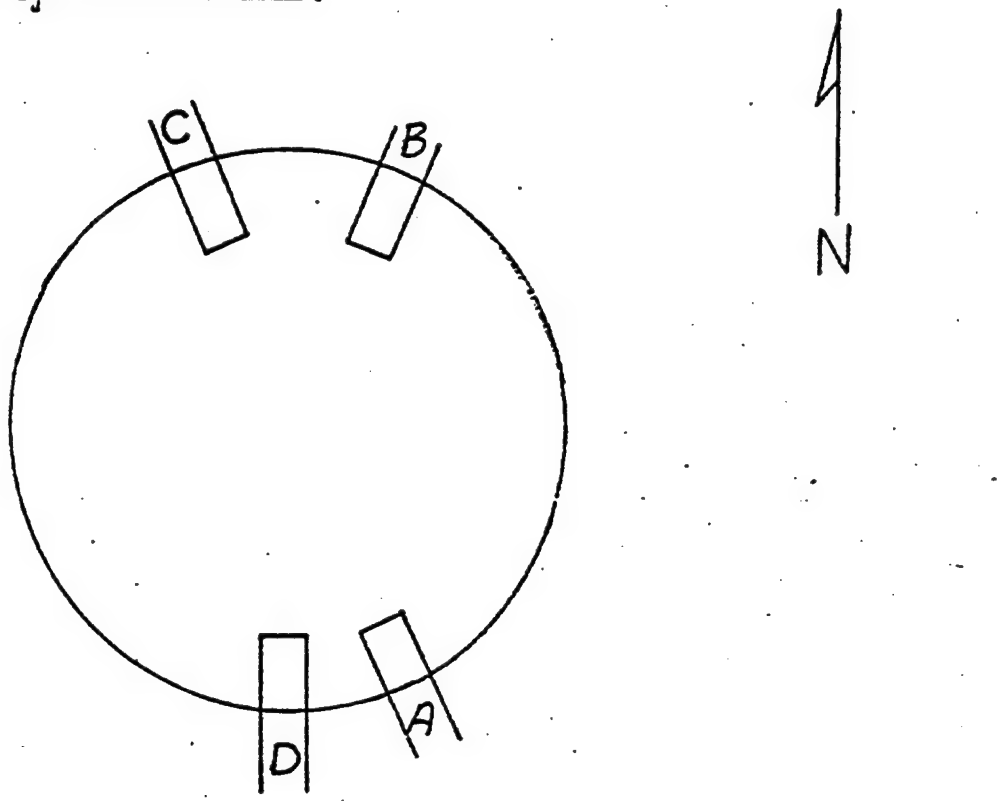
Line	Size	Mat'l	Depth*	Service
A	12"	TILE	13'-2"	INLET FROM E-2
B	12"	TILE	13'-2"	OUTLET TO BLDG 503
C				
D				
E				
F				

* From Top Ring

Manhole Number E-2

Approximate Depth* 13'-1"

System: contaminated sewer E-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 505'-2" W 1128'-10"

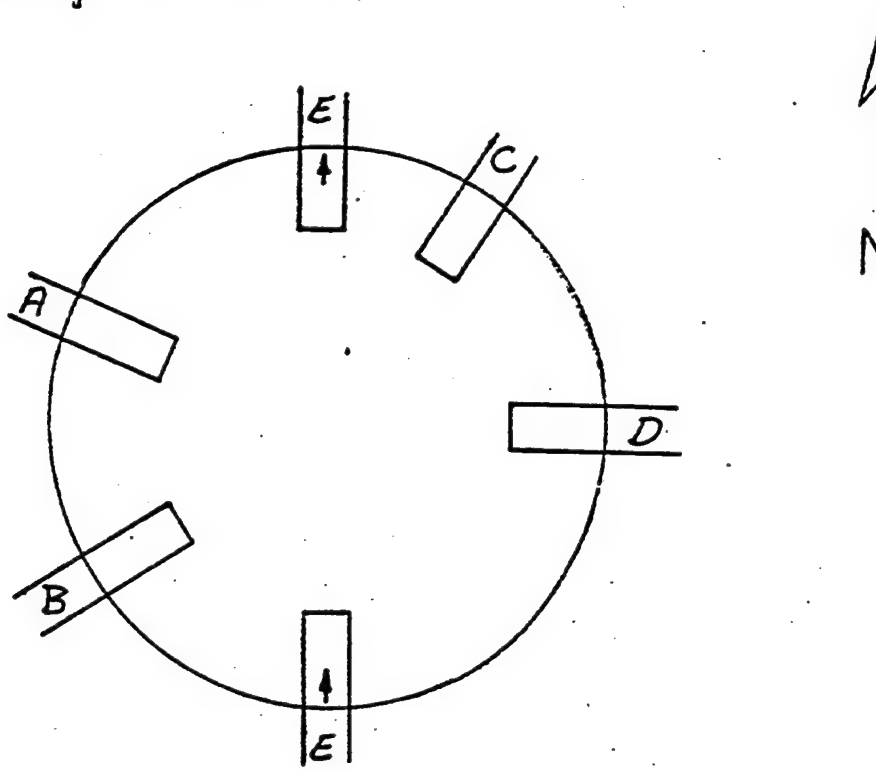
Line	Size	Mat'l	Depth*	Service
A	4"	STL	3'-6"	TANK TRUCK LOADING PAD DRAINS
B	12"	TILE	13'-1"	OUTLET TO E-11
C	12"	TILE	13'-1"	OUTLET TO E-1
D	12"	TILE	13'-1"	INLET FROM E-3
E				
F				

* From Top Ring

Manhole Number E-3

Approximate Depth* 11'-3½"

System: contaminated sewer ~~XE-13347~~, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 432'-1" W 1129'-10"

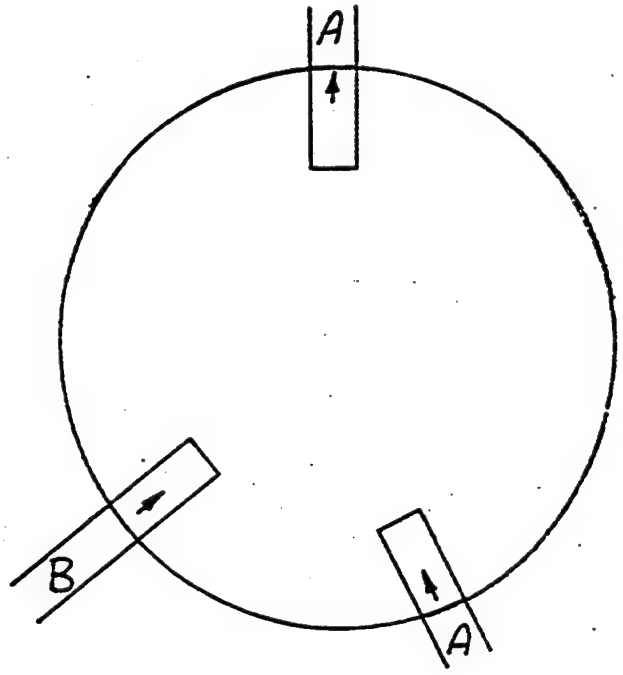
Line	Size	Mat'l	Depth*	Service
A	4"	CONC	4'-10"	TANK PAD AREA DRAIN
B	6"	CONC	6'-1"	TANK FARM AREA DRAIN
C	4"	CONC	4'-9"	FLR. DRAIN BLDG 514E
D	4"	CONC	9'-0"	TANK FARM AREA DRAIN
E	12"	TILE	11'-3½"	INLET FROM E-4 OUTLET TO E-2
F				

* From Top Ring

Manhole Number E4

Approximate Depth* 9'-10"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 360'-1" W 1130'-10"

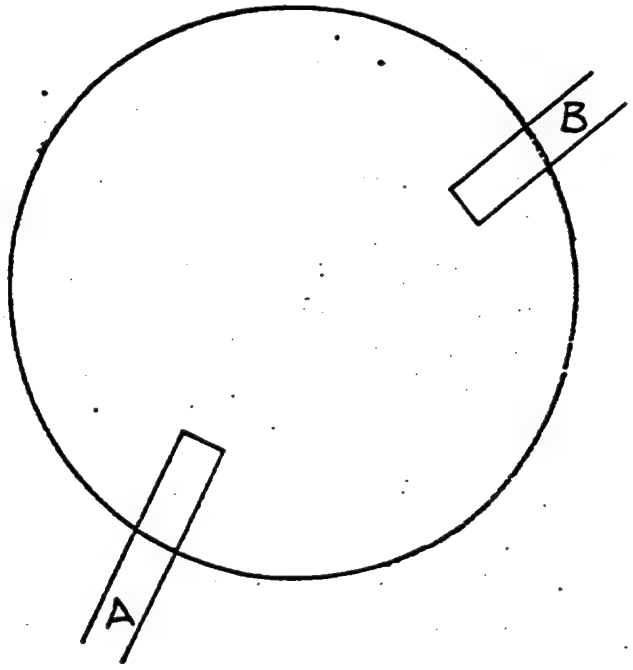
Line	Size	Mat'l	Depth*	Service
A	12"	TILE	9'-10"	INLET FROM E-5, OUTLET TO E-3
B	8"	TILE	8'-10"	INLET FROM E4A
C				
D				
E				
F				

* From Top Ring

Manhole Number E4A

Approximate Depth* 8'-8"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-351'-7" W-1139'-4"

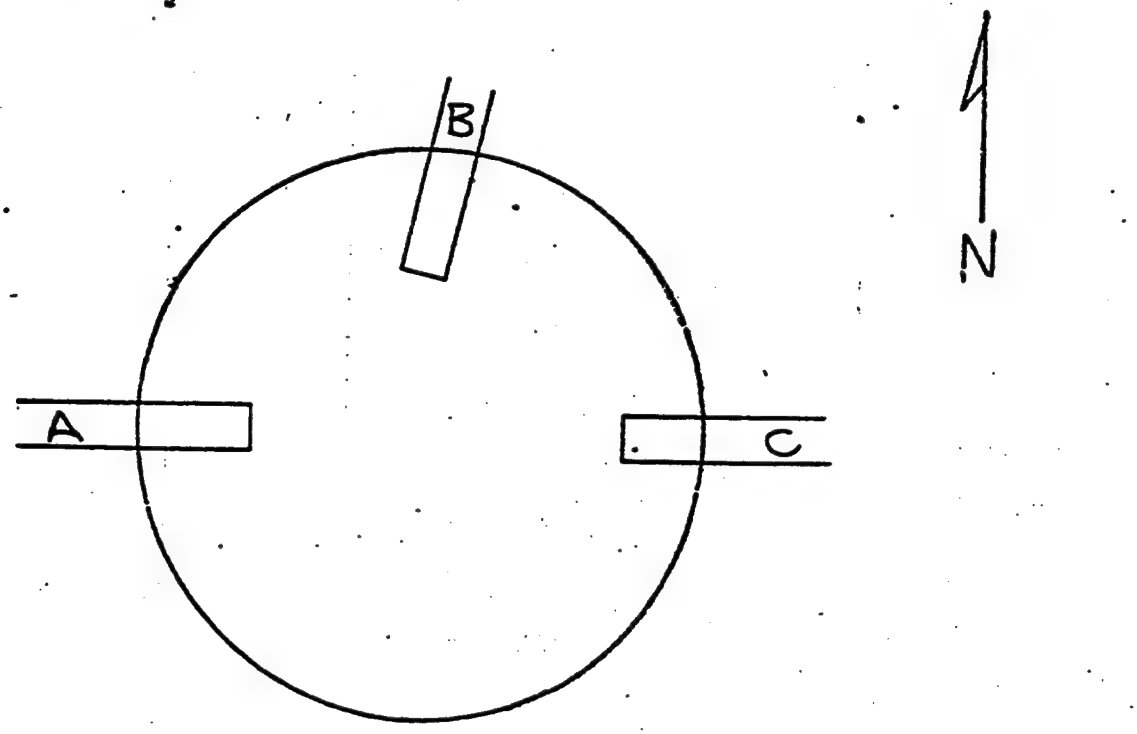
Line	Size	Mat'l	Depth*	Service
A	8"	TILE	8'-8"	INLET FROM E4B
B	8"	TILE	8'-8"	OUTLET TO E4
C				
D				
E				
F				

* From Top Ring

Manhole Number E4B

Approximate Depth* 8'-0"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-337'-10" W-1140'-6"

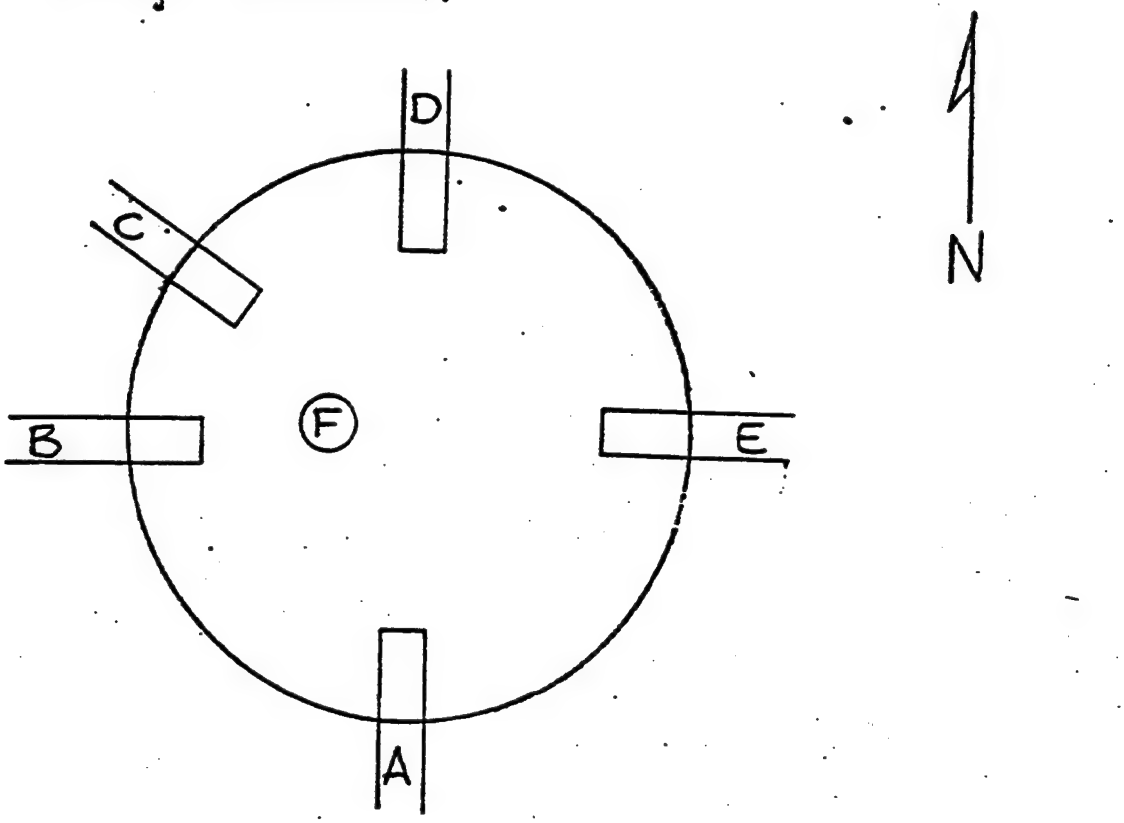
Line	Size	Mat'l	Depth *	Service
A	8"	TILE	8'-0"	INLET FROM E5A
B	8"	TILE	8'-0"	OUTLET TO E4A
C	8"	TILE	8'-0"	ABANDON
D				
E				
F				

* From Top Ring

Manhole Number E5

Approximate Depth* 9'-10"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-338'-10" W-1113'-0"

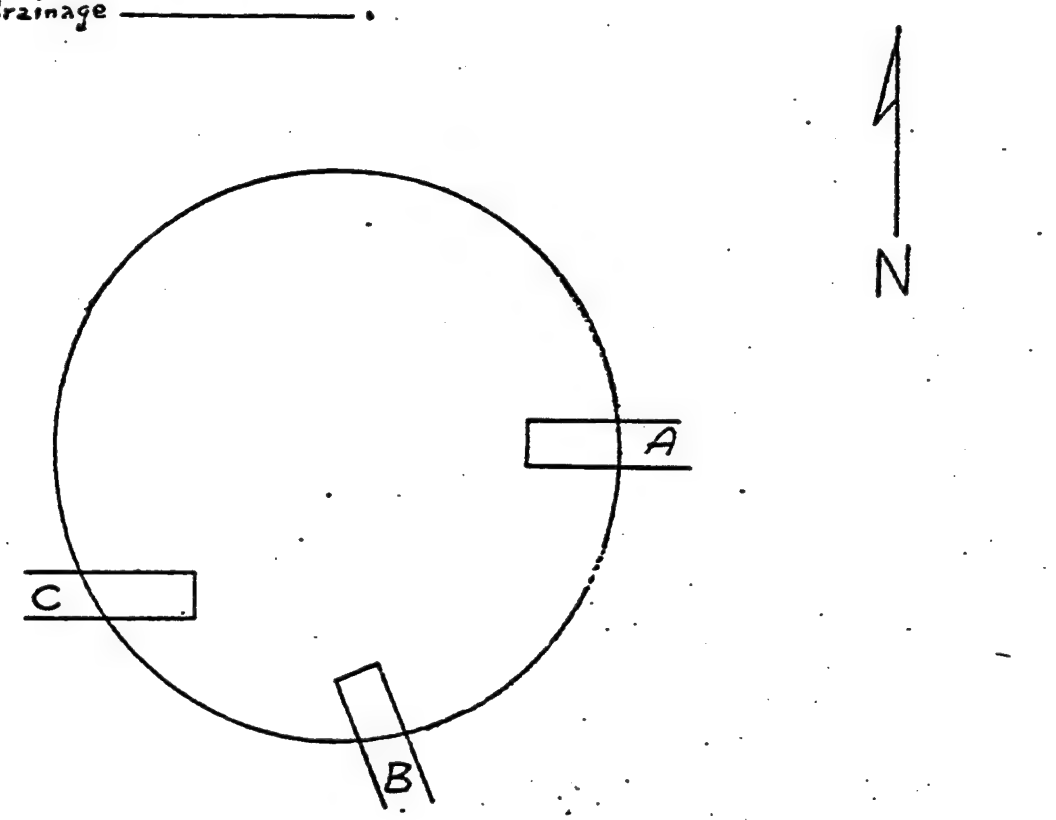
Line	Size	Mat'l	Depth *	Service
A	12"	TILE	9'-10"	INLET FROM [redacted] E6
B	8"	TILE	8'-10"	ABANDON
C	4"	CONC	4'-4"	BLDG 514C
D	12"	TILE	9'-10"	OUTLET TO E4
E	4"	CONC	3'-10"	AREA DRAIN BLDG 509
F	3"	STL	IN TOP	MMCAA EMERGENCY OVERFLOW BLDG 514 TANK ROOM

* From Top Ring

Manhole Number E5A

Approximate Depth* 7'-0"

System: contaminated sewer E-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 315'-4" W 1353-10"

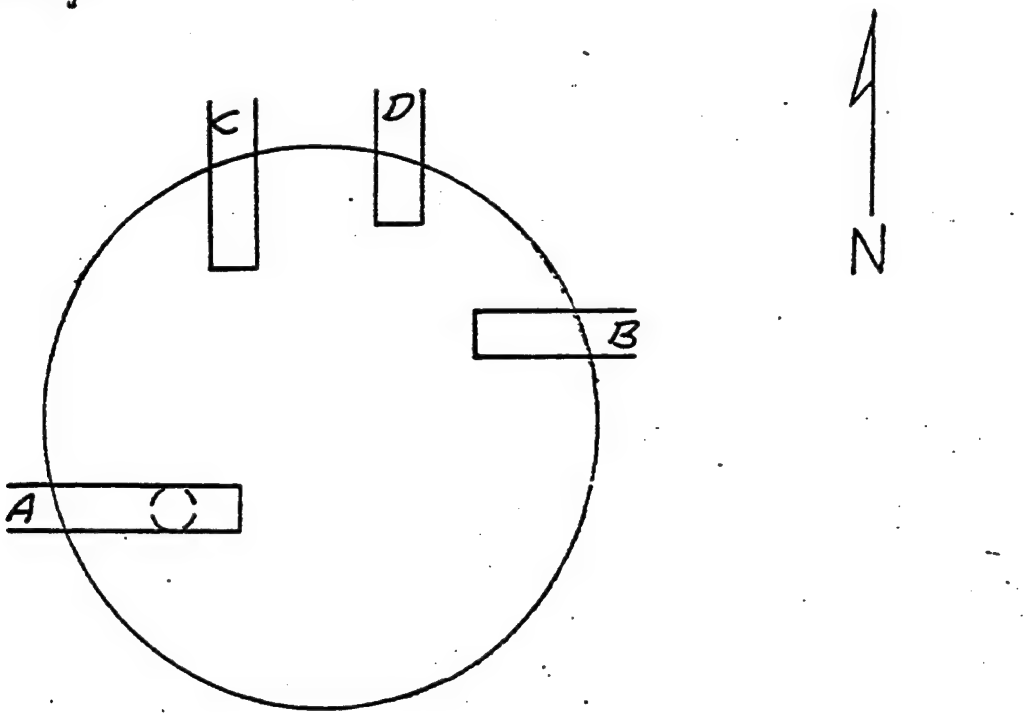
Line	Size	Mat'l	Depth*	Service
A	8"	CONC	7'-0"	OUTLET TO E4A
B	8"	CONC	7'-0"	BLDG 514 WEST SUMP
C	8"	STL	6'-5"	INLET FROM E5B
D				
E				
F				

* From Top Ring

Manhole Number E5B

Approximate Depth* 7'-8"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 312'-9" W 1410'-10"

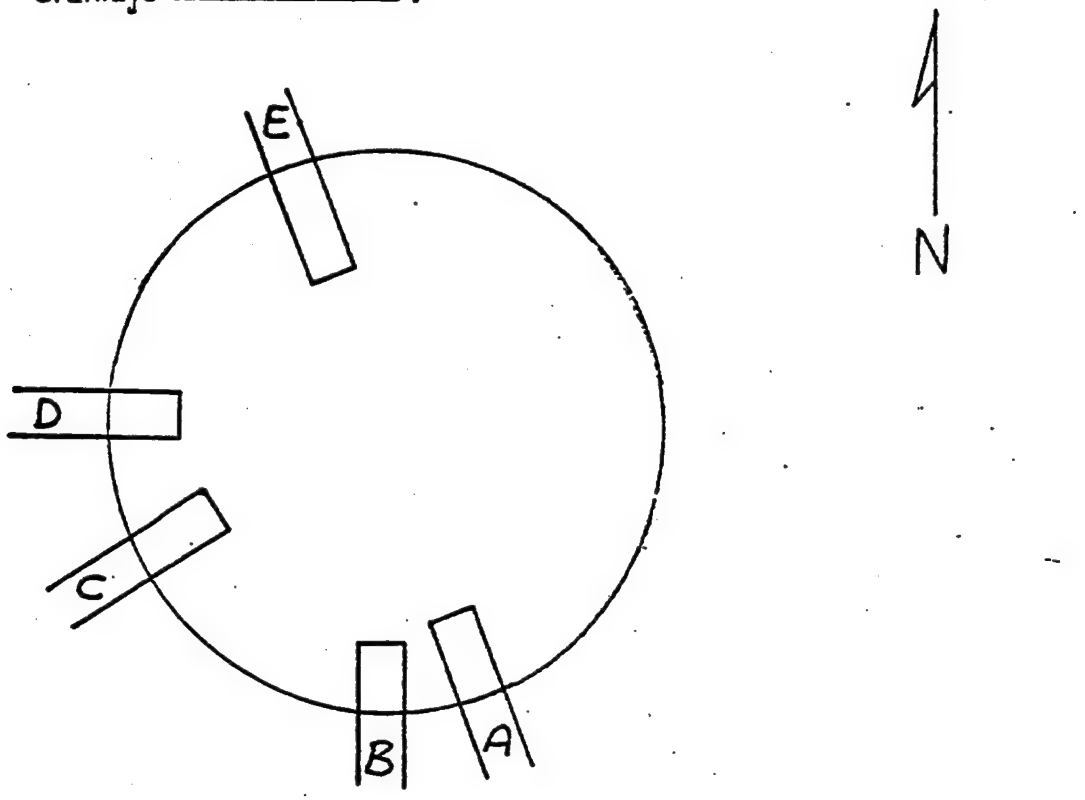
Line	Size	Mat'l	Depth*	Service
A	8"	STL	6'-0"	ABANDON
B	8"	STL	6'-4"	OUTLET TO 5A
C	4"	CONC	4'-9"	TANK FARM TRENCH DRAINS
D	2"	PLASTIC	1'-10"	BLDG 561 FLR TRENCH DRAINS
E				
F				

* From Top Ring

Manhole Number E-6

Approximate Depth* 6'-6"

System: contaminated sewer XE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 257'-5½" W 1095'-6"

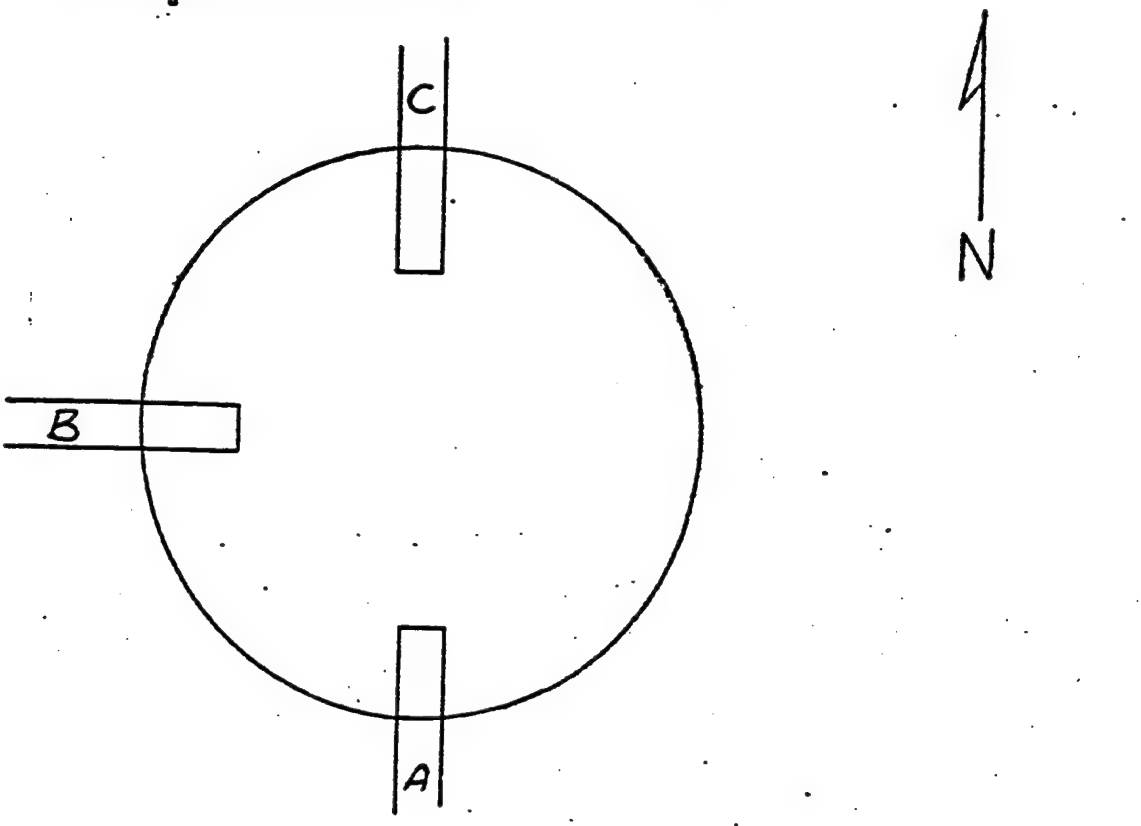
Line	Size	Mat'l	Depth*	Service
A	12"	TILE	6'-6"	INLET FROM E7
B	4"	CONC	2'-2"	FLOOR DRAIN BLDG 529
C	4"	CONC	4'-2"	TRENCH DRAIN, P-1627 DRAIN
D	4"	CONC	4'-0"	AREA DRAIN
E	12"	TILE	6'-6"	OUTLET TO E5
F				

* From Top Ring

Manhole Number E-7

Approximate Depth* 5'-7½"

System: contaminated sewer XE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 185'-1½" W 1095'-6"

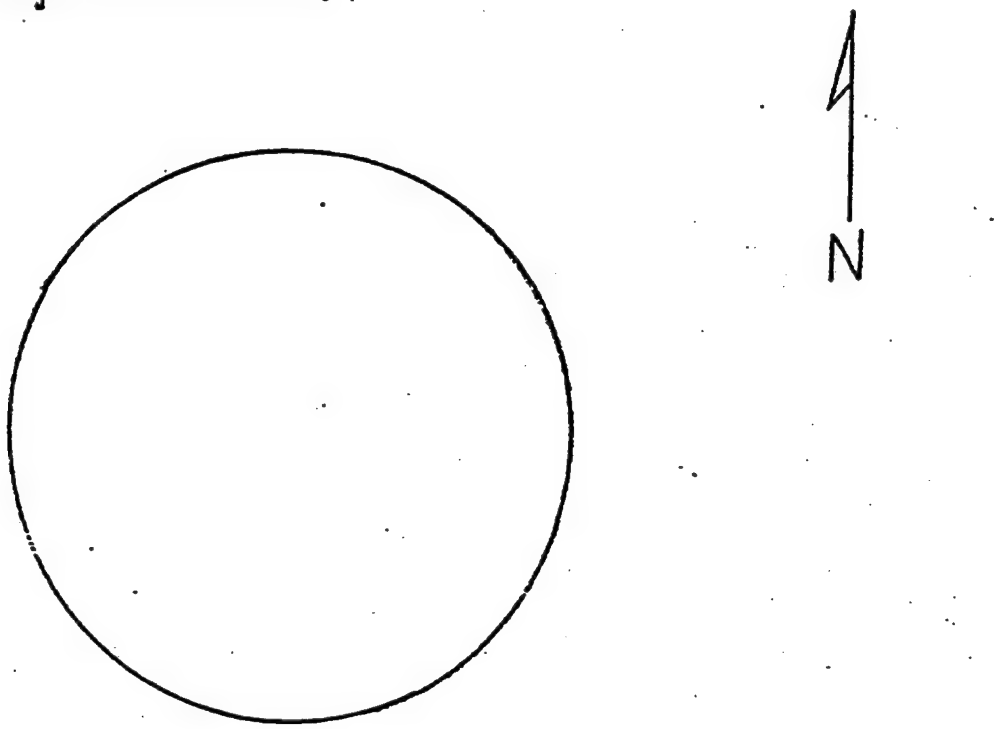
Line	Size	Mat'l	Depth*	Service
A	10"	CONC	4'-8"	INLET FROM E-9, FLOOR DRAIN BLDG 528
B	12"	TILE	5'-7½"	INLET FROM E-8
C	12"	TILE	5'-7½"	OUTLET TO E-6
D				
E				
F				

* From Top Ring

Manhole Number E-8

Approximate Depth* _____

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 183'-1½" W 1162'-10"

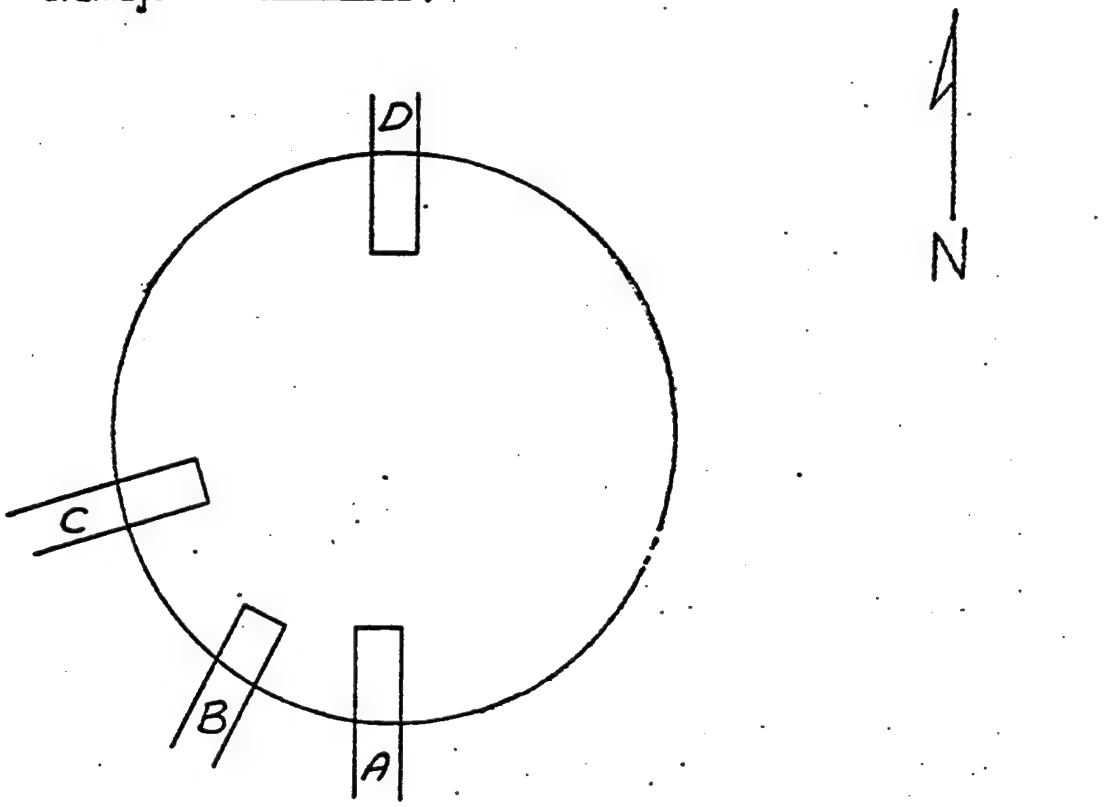
Line	Size	Mat'l	Depth*	Service
A				
B				
C				
D				
E				
F				

* From Top Ring

Manhole Number E-9

Approximate Depth* 2'-3"

System: contaminated sewer XE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 37'-4½" W 1121'-8"

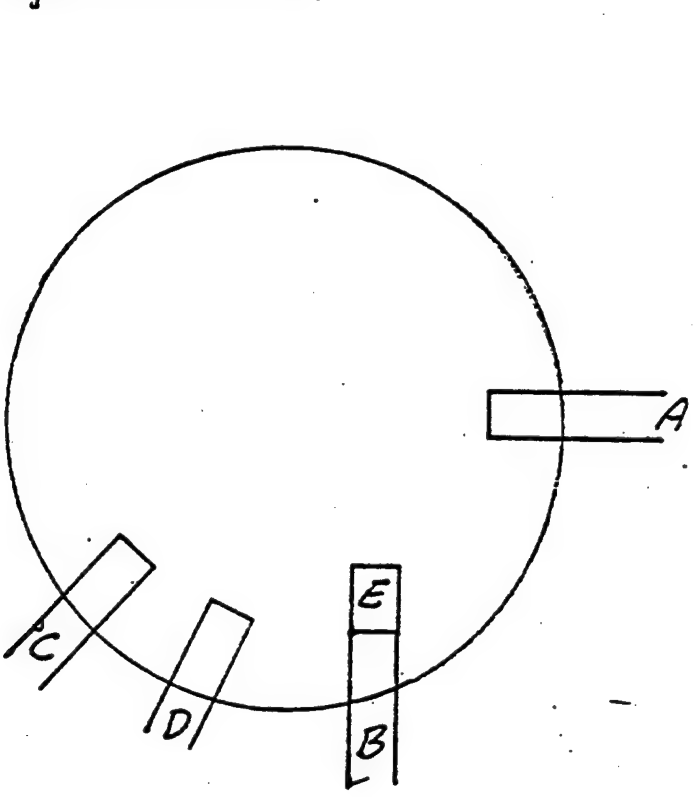
Line	Size	Mat'l	Depth *	Service
A	10"	TILE	2'-3"	INLET FROM E-10
B	4"	STL	2'-1"	ABANDON
C	6"	CONC	2'-1"	
D	10"	TILE	2'-3"	OUTLET TO E-7
E				
F				

* From Top Ring

Manhole Number E-10

Approximate Depth* 2'-2"

System: contaminated sewer ~~E-13347~~, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 35'-7½" W 1290'-1"

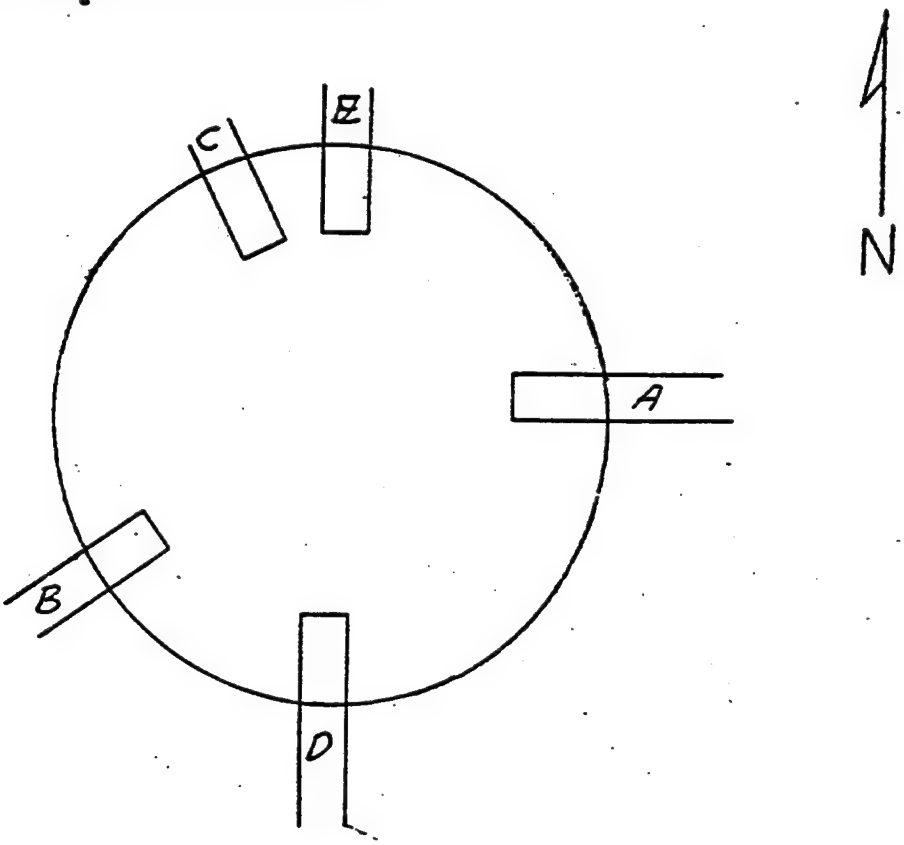
Line	Size	Mat'l	Depth*	Service
A	8"	CONC	2'-2"	OUTLET TO E-9
B	6"	TILE	12"	BLDG 525 TANK FARM
C	4"	STL	10"	FLOOR DRAIN BLDG 526
D	1½"	STL	15"	ABANDON
E	6"	STL	2'-2"	BLDG 521
F				

* From Top Ring

Manhole Number E-11

Approximate Depth* 13'-11½"

System: contaminated sewer ~~YE~~-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 543'-3" W 1110'-3⅞"

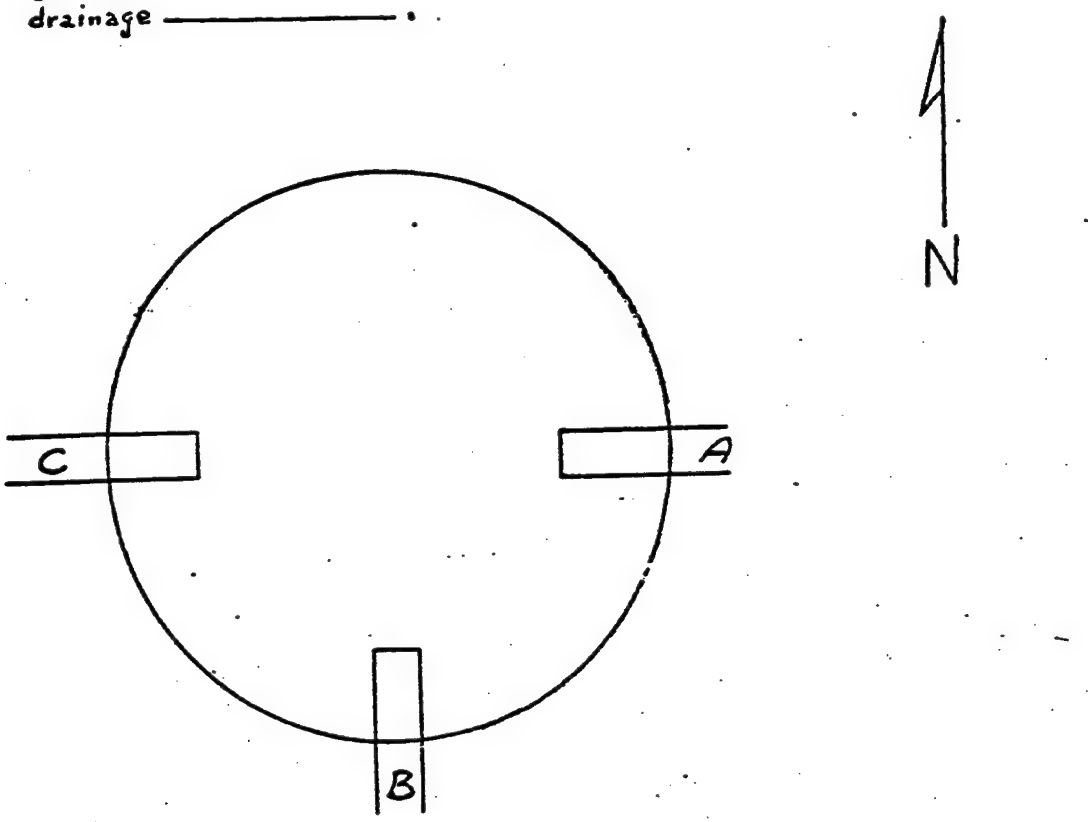
Line	Size	Mat'l	Depth*	Service
A	12"	STL	9'-3"	INLET FROM E-12
B	4"	STL	9'-11"	ABANDON
C	12"	TILE	13'-11½"	OUTLET TO THE EAST METER
D	12"	TILE	13'-11½"	INLET FROM E-2
E	12"	TILE	13'-11½"	ABANDON
F				

* From Top Ring

Manhole Number E 12

Approximate Depth* 7'-10"

System: contaminated sewer XE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-520'-0" W 901'-10"

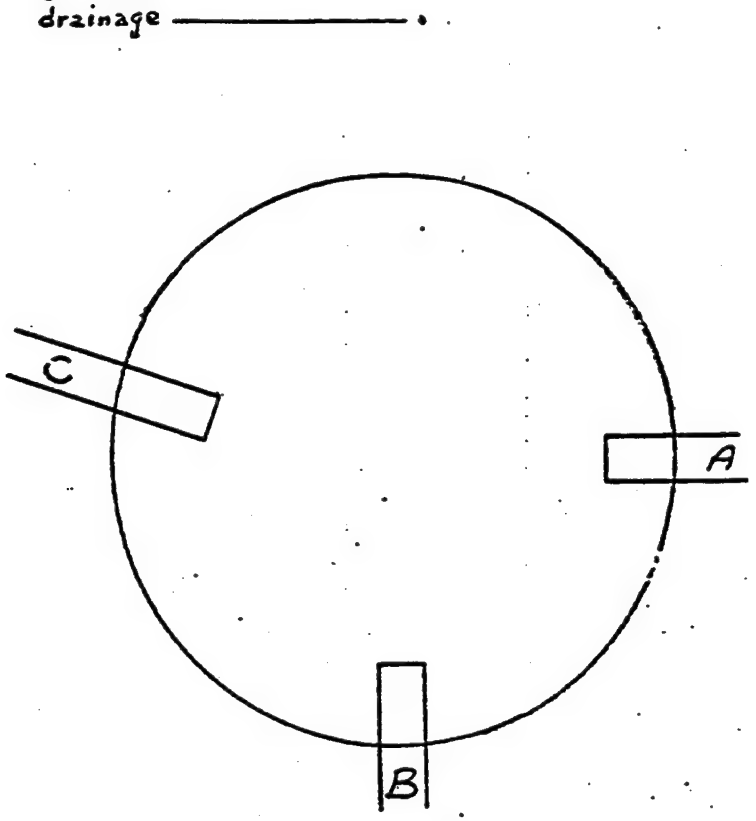
Line	Size	Mat'l	Depth*	Service
A	12"	TILE	7'-10"	INLET FROM E-13
B	6"	TILE	7'-10"	INLET FROM E-15
C	12"	TILE	7'-10"	OUTLET TO E-11
D				
E				
F				

* From Top Ring

Manhole Number E13

Approximate Depth* 7'-4"

System: contaminated sewer XE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 502'-4" W 752'-6"

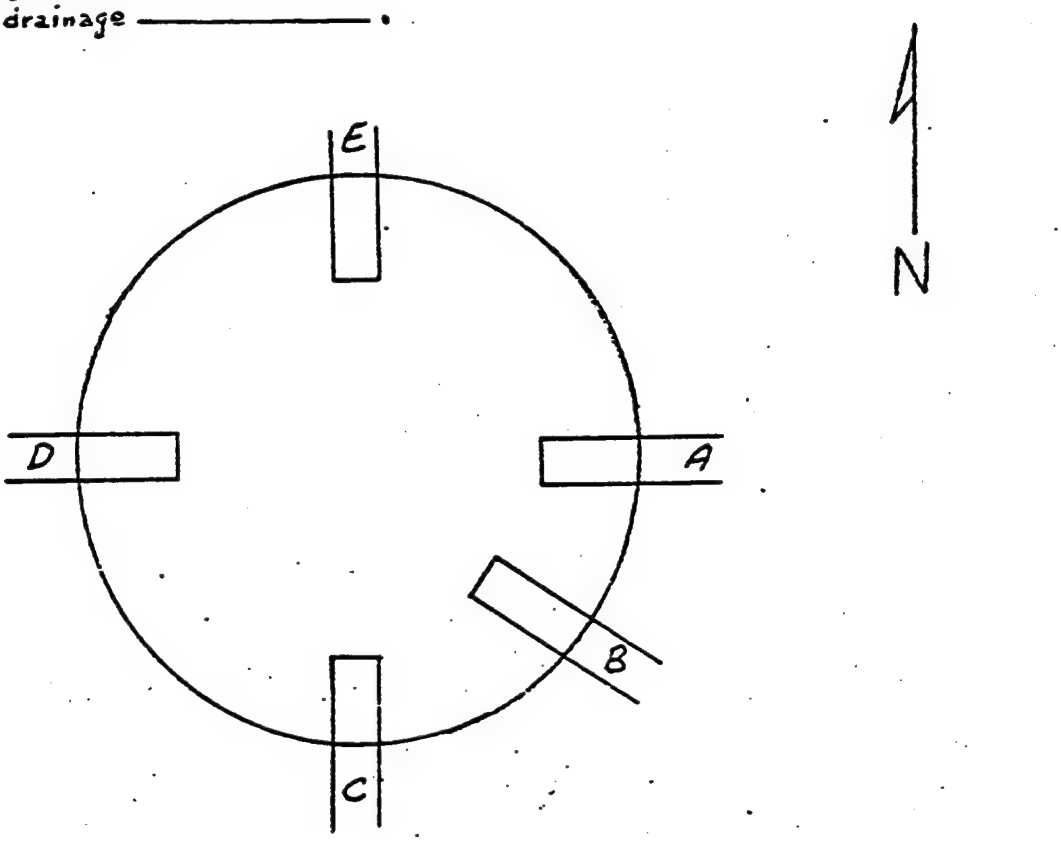
Line	Size	Mat'l	Depth *	Service
A	10"	TILE	7'-4"	BLDG 724, DET AREA DRAINS
B	10"	TILE	7'-0"	INLET FROM E-14
C	12"	TILE	7'-4"	OUTLET TO E-12
D				
E				
F				

* From Top Ring

Manhole Number E15

Approximate Depth* 4'-10"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 429'-0" W 859'-4"

Line	Size	Mat'l	Depth*	Service
A	6"	CONC	4'-7"	FLAME TOWER PAD DRAIN
B	4"	STL	3'-8"	BLDG 571 SUMP
C	6"	TILE	4'-10"	KNOCK-OUT POT PAD DRAIN, BLDG 5718
D	4"	CONC	3'-8"	TANK FARM AREA DRAIN
E	6"	TILE	4'-10"	OUTLET TO E-12
F				

* From Top Ring

MANHOLE NUMBER E-16

APPROXIMATE DEPTH* 4'-1"

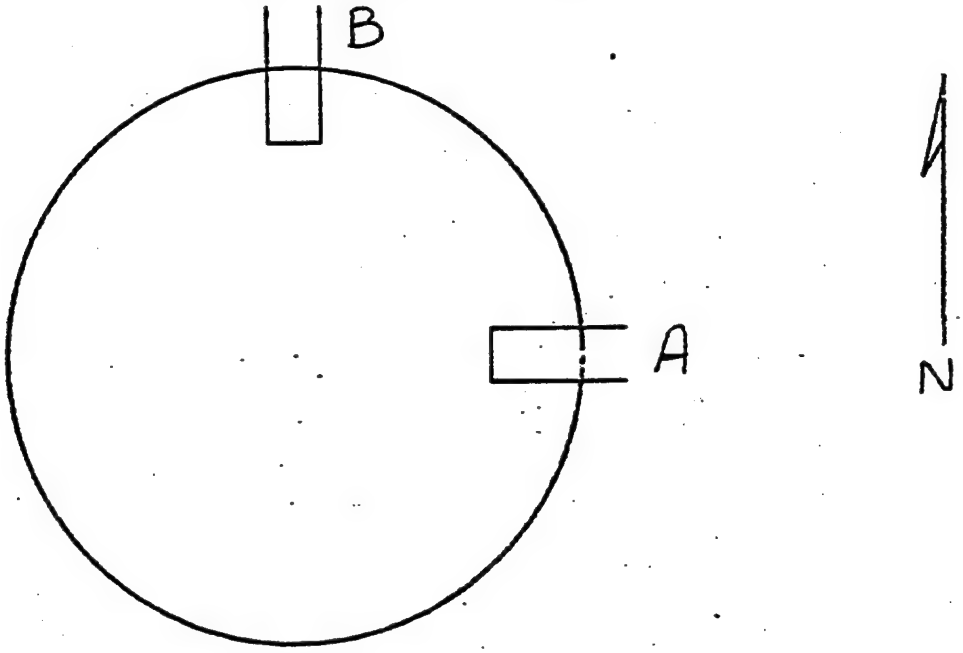
SYSTEM:

CONTAMINATED SEWER YE- 13347

SANITARY SEWER

PWR

SURFACE DRAINAGE



LOCATION South of Bldg. 728

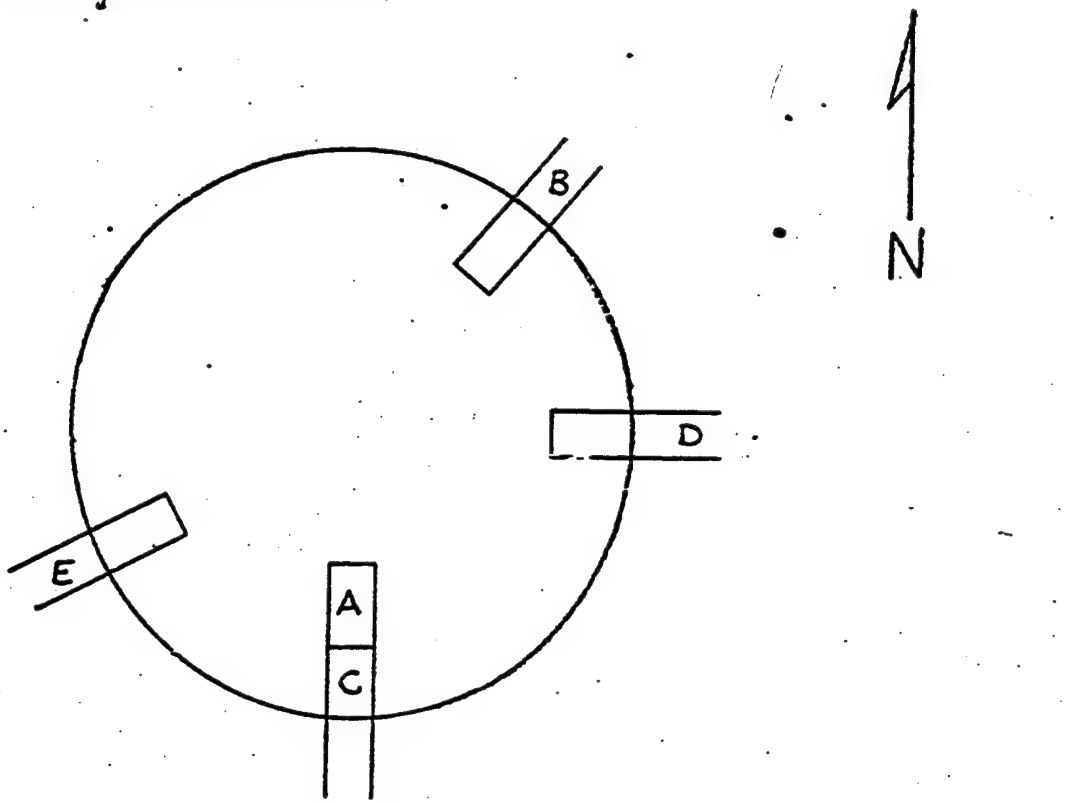
LINE	SIZE	MAT'L.	DEPTH*	SERVICE
A	6"	C. Steel	4'-1"	Inlet from Tank Car Loading
B	6"	C. Steel	4!-1"	Outlet to Existing 6" C. Sewer Line
C				
D				
E				
F				

* FROM TOP RING

Manhole Number W-1

Approximate Depth* 10'-9"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-537'-6" W-1731'-10"

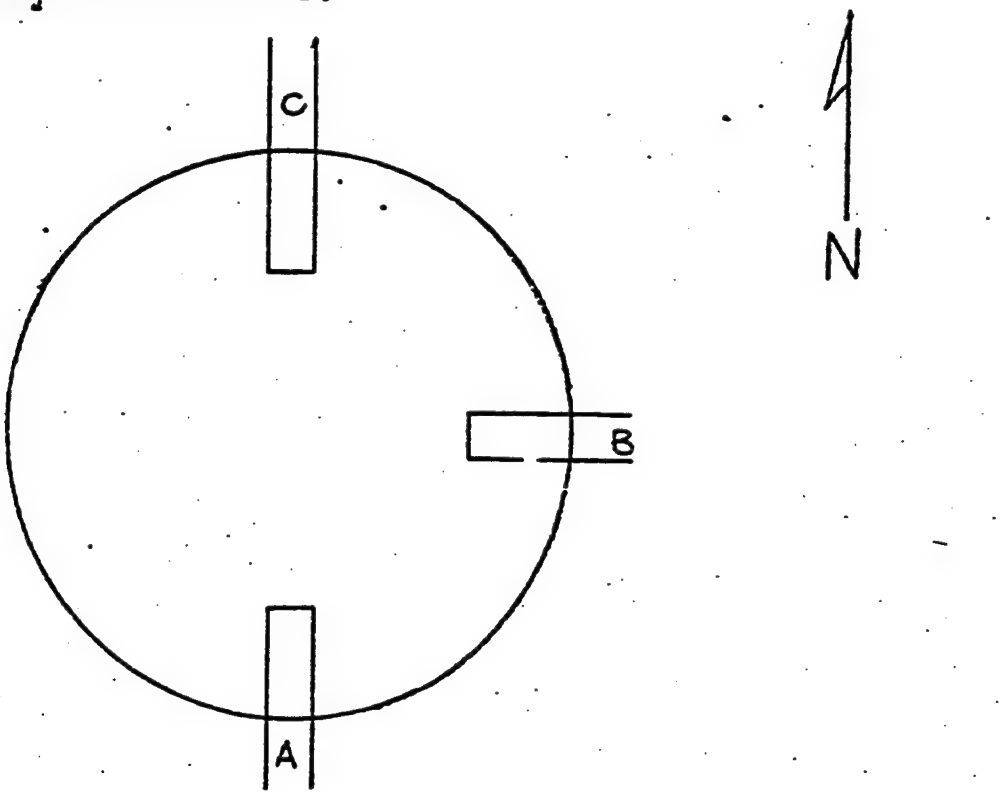
Line	Size	Mat'l	Depth*	Service
A	12"	TILE	10'-9"	FROM W-7 & V-1230 AREA
B	10"	TILE	10'-9"	TO W-1A
C	4"	STL	3'-2"	T-1010, T-15, T-14 AREA
D	6"	STL	5'-0"	BLDG 561 AREA
E	10"	TILE	10'-0"	FROM W-2
F				

* From Top Ring

Manhole Number W1A

Approximate Depth* 10'-10"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-559'-0" W-1730'-4"

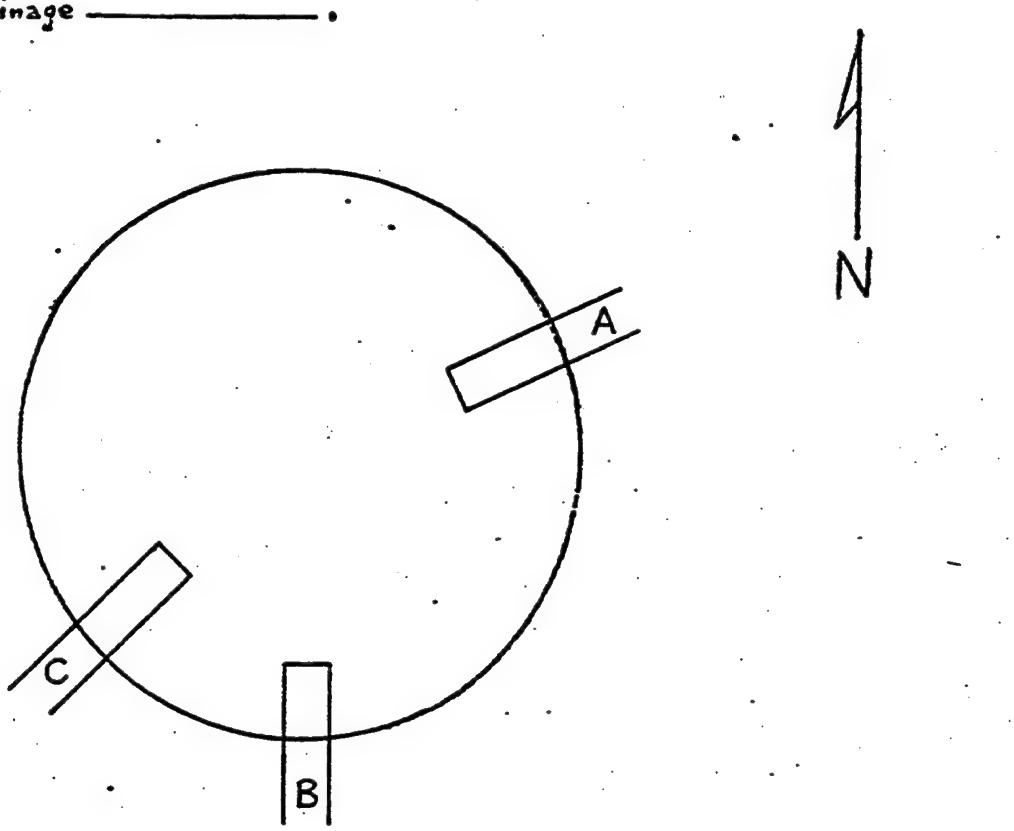
Line	Size	Mat'l	Depth*	Service
A	10"	TILE	10'-10"	FROM W-1
B	12"	TILE	10'-10"	TO BLDG 502 SUMP
C	10"	TILE	10'-10"	TO WEST METER
D				
E				
F				

* From Top Ring

Manhole Number W 2

Approximate Depth* 9'-6"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-517'-6" W-1982'-10"

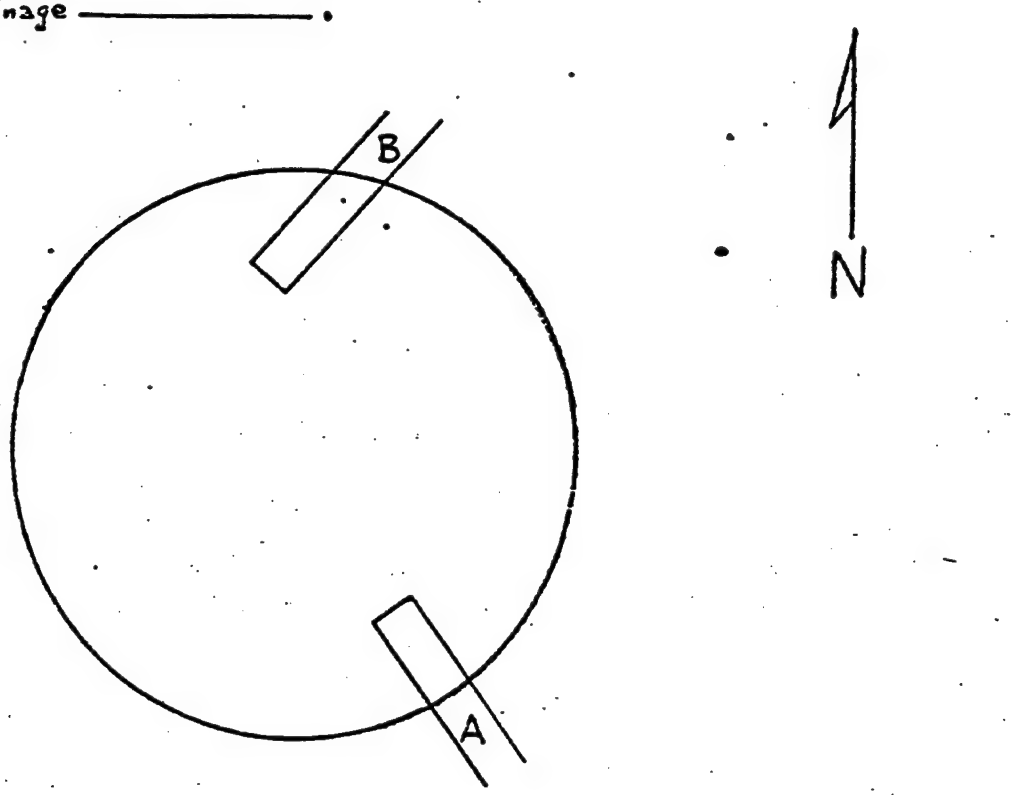
Line	Size	Mat'l	Depth *	Service
A	10"	TILE	9'-6"	OUTLET TO W-1
B	10"	TILE	9'-6"	ABANDON
C	10"	TILE	9'-6"	INLET FROM W-3
D				
E				
F				

* From Top Ring

Manhole Number W 3

Approximate Depth* 8'-6"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-489'-6" W-2006'-10"

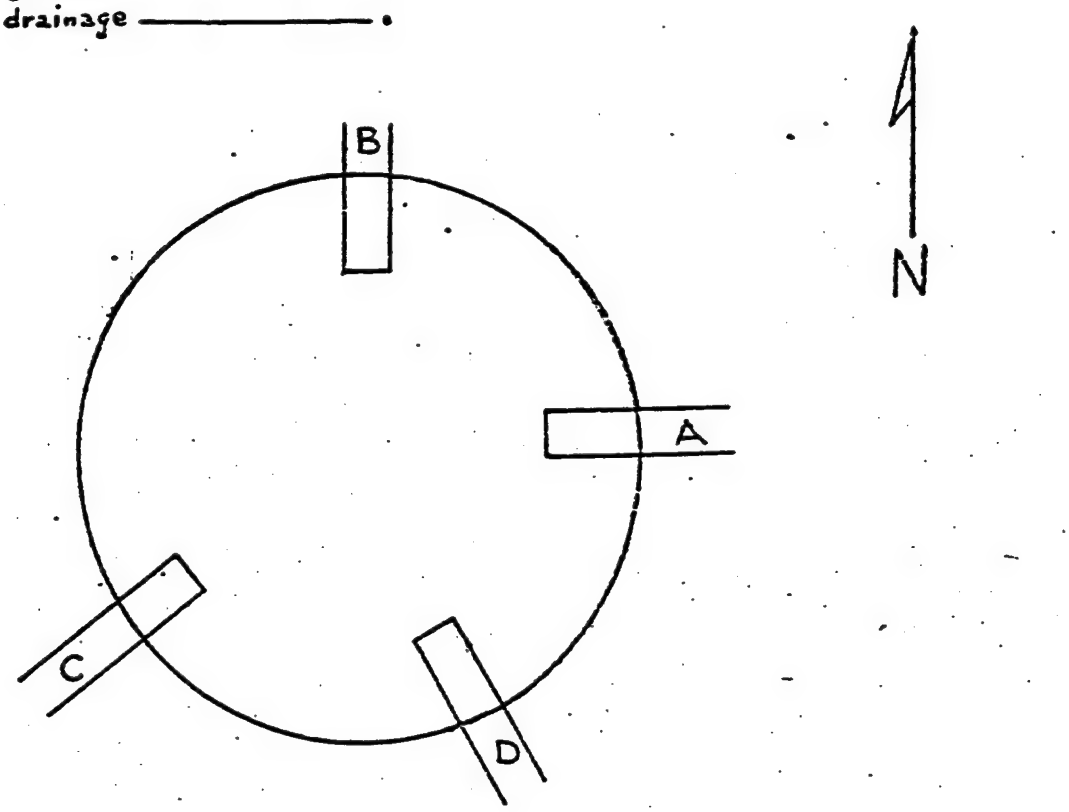
Line	Size	Mat'l	Depth*	Service
A	10"	TILE	8'-6"	INLET FROM W-4
B	10"	TILE	8'-6"	OUTLET TO W-2
C				
D				
E				
F				

* From Top Ring

Manhole Number W4

Approximate Depth* 7'-9"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-425'-6" W-1983'-10"

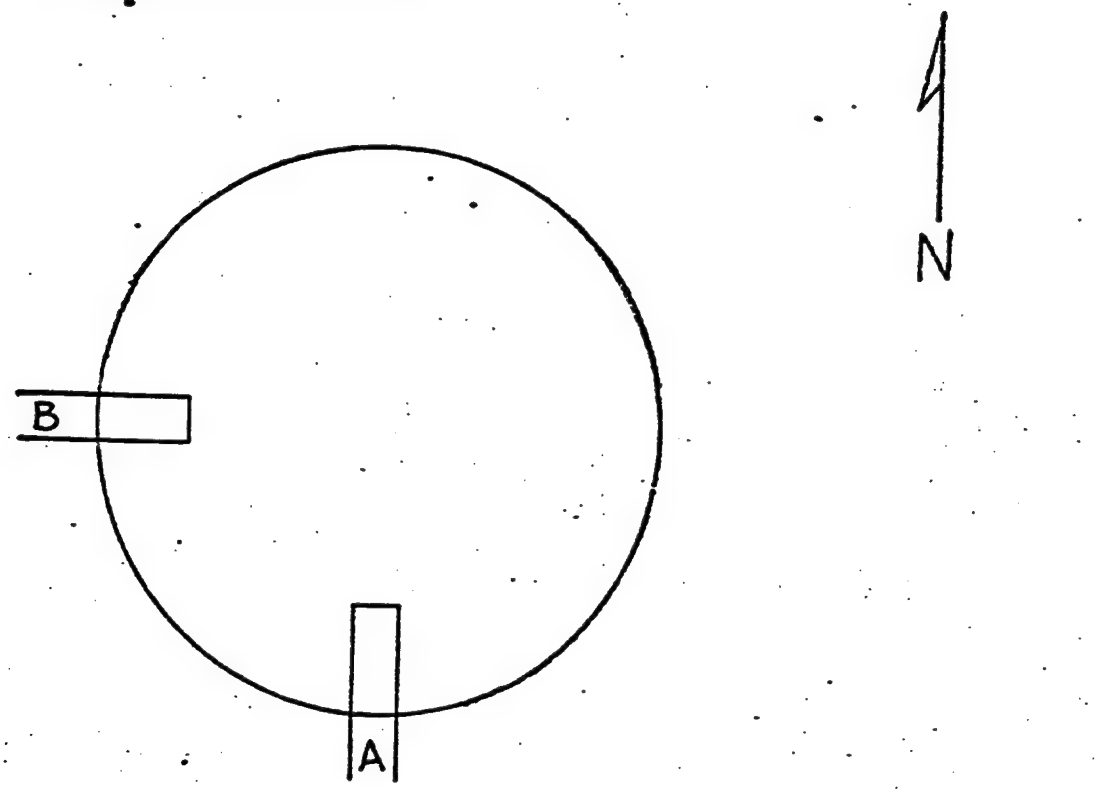
Line	Size	Mat'l	Depth *	Service
A	4"	TILE	6'-0"	INLET FROM W-4A, BLDG 534B SUMP
B	10"	TILE	7'-9"	OUTLET TO W-3
C	10"	CONC	7'-9"	INLET FROM W-5
D	4"	TILE	3'-2"	4" AREA DRAIN
E				
F				

* From Top Ring

Manhole Number W4A

Approximate Depth* 3'-9"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-425'-6" W-1937'-10"

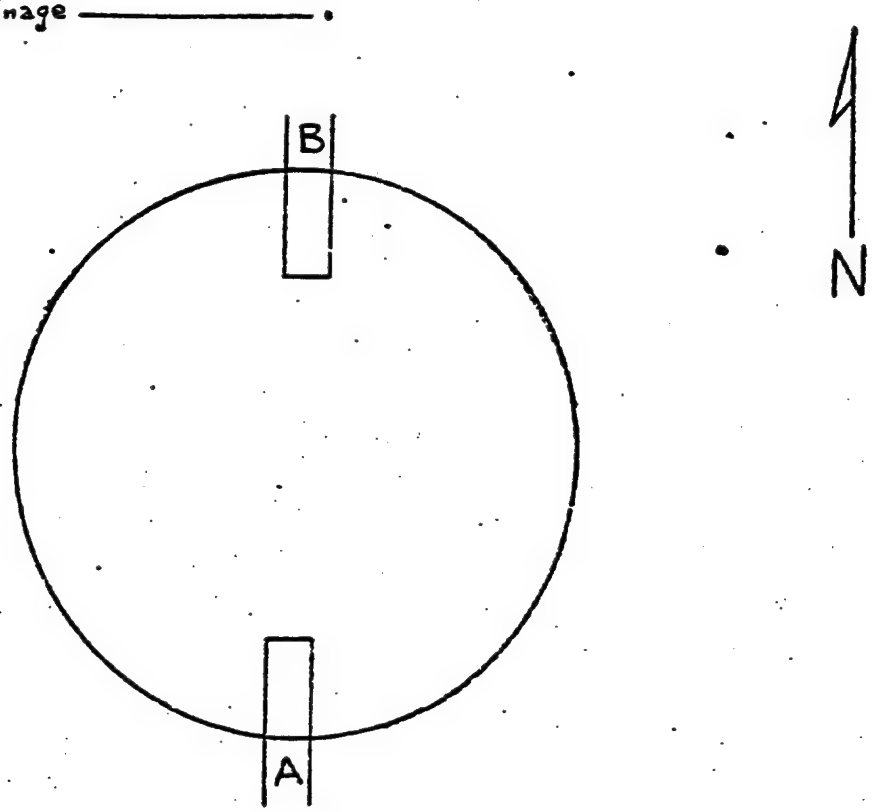
Line	Size	Mat'l	Depth*	Service
A	4"	TILE	3'-4"	BLDG 534B AREA DRAINS
B	4"	TILE	3'-9"	OUTLETTO W-4
C				
D				
E				
F				

* From Top Ring

Manhole Number W 5

Approximate Depth* 7'-0"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-401'-6" W-1997'-10"

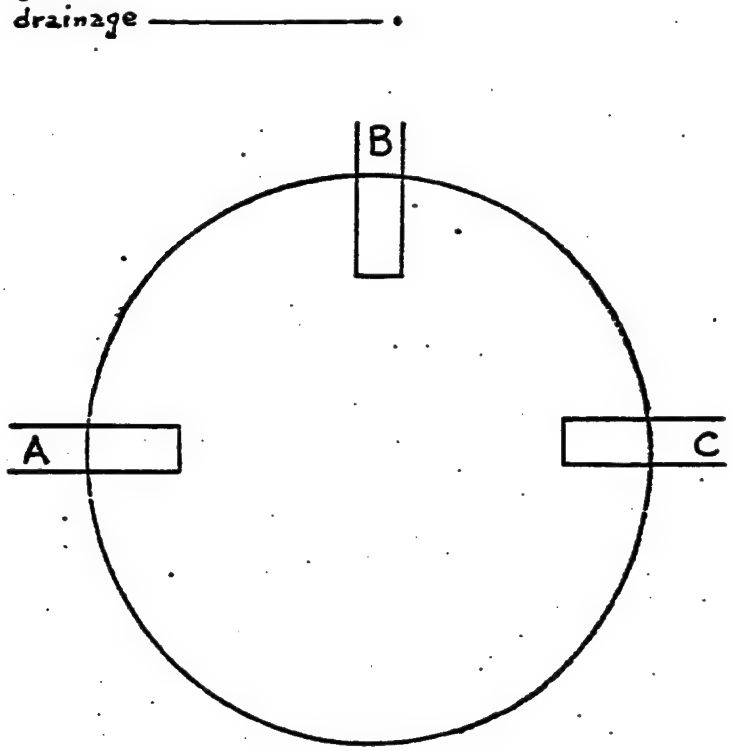
Line	Size	Mat'l	Depth*	Service
A	10"	TILE	7'-0"	OUTLET TO W-4
B	10"	TILE	7'-0"	INLET FROM W-6
C				
D				
E				
F				

* From Top Ring

Manhole Number W6

Approximate Depth* 6'-10"

System: contaminated sewer VE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-383'-0" W-1997'-10"

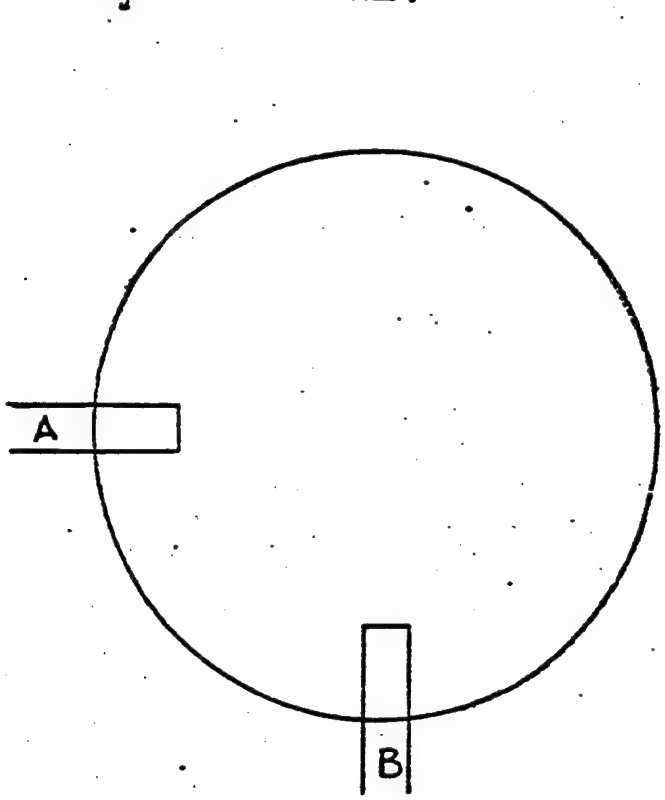
Line	Size	Mat'l	Depth*	Service
A	8"	TILE	6'-10"	FROM BLDG 532
B	10"	TILE	6'-10"	OUTLET TO W-5
C	8"	CONC	5'-1"	FROM BLDG 534B
D				
E				
F				

* From Top Ring

Manhole Number W6A

Approximate Depth* 5'-0"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-275'-0" W-2017'-10"

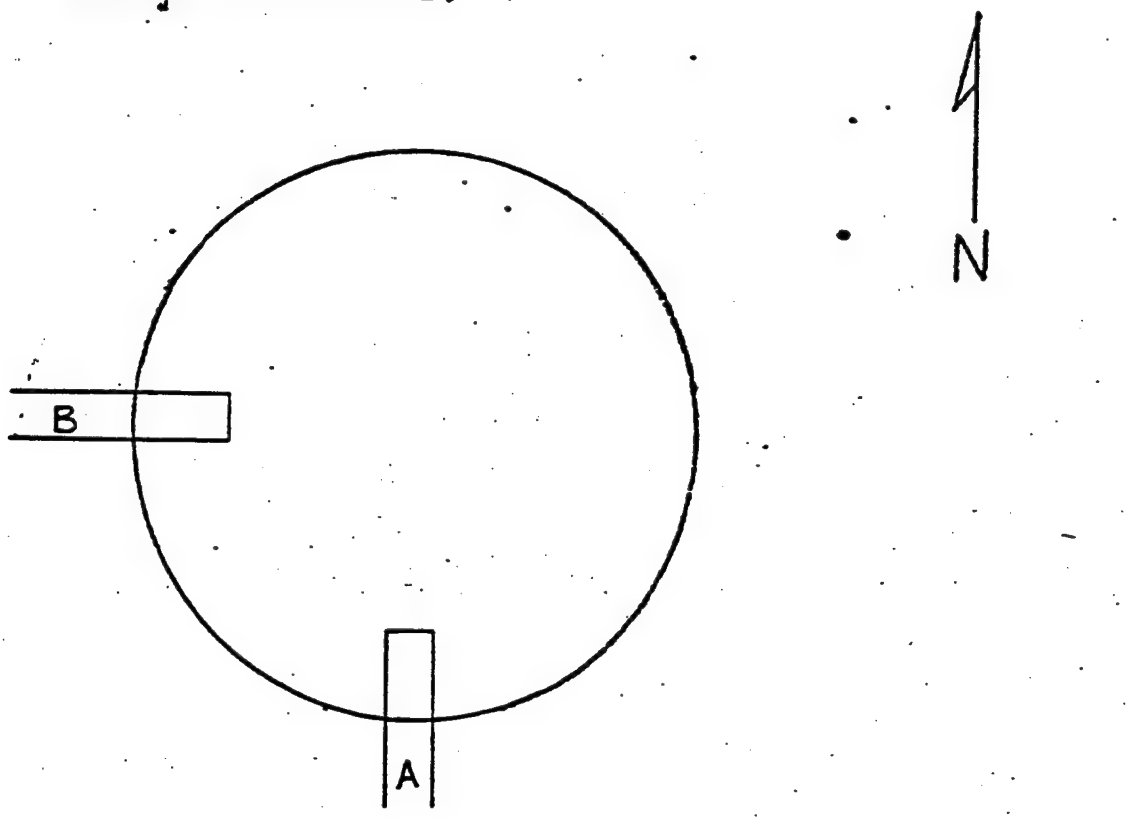
Line	Size	Mat'l	Depth *	Service
A	8"	TILE	5'-0"	FROM BLDG 532
B	8"	TILE	5'-0"	TO BLDG 532 SUMP
C				
D				
E				
F				

* From Top Ring

Manhole Number W-6B

Approximate Depth* 4'-0"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-256'-6" W-1989-4"

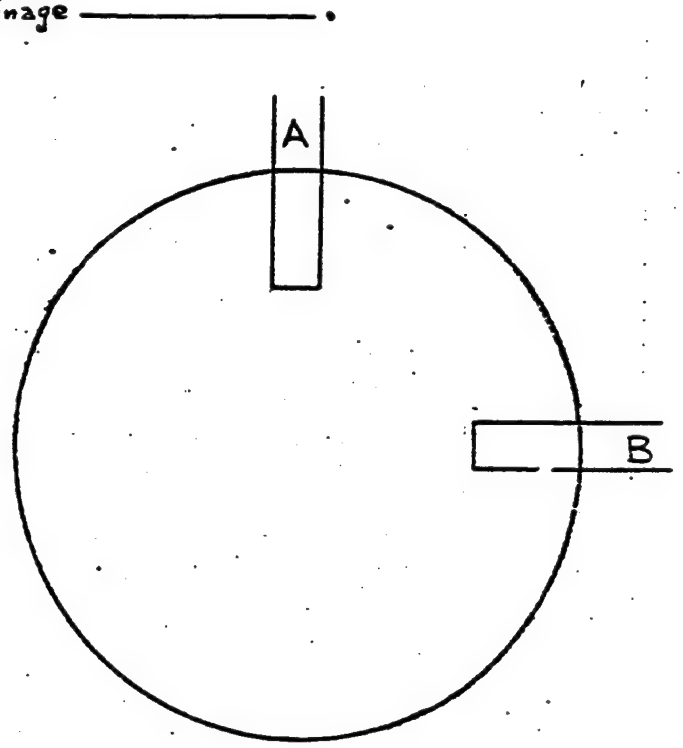
Line	Size	Mat'l	Depth*	Service
A	6"	TILE	3'-0"	INLET FROM W-6C
B	6"	TILE	4'-0"	TO BLDG 532 SUMP
C				
D				
E				
F				

* From Top Ring

Manhole Number W6C

Approximate Depth* 3'-0"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-98'-6" W-1989'-4"

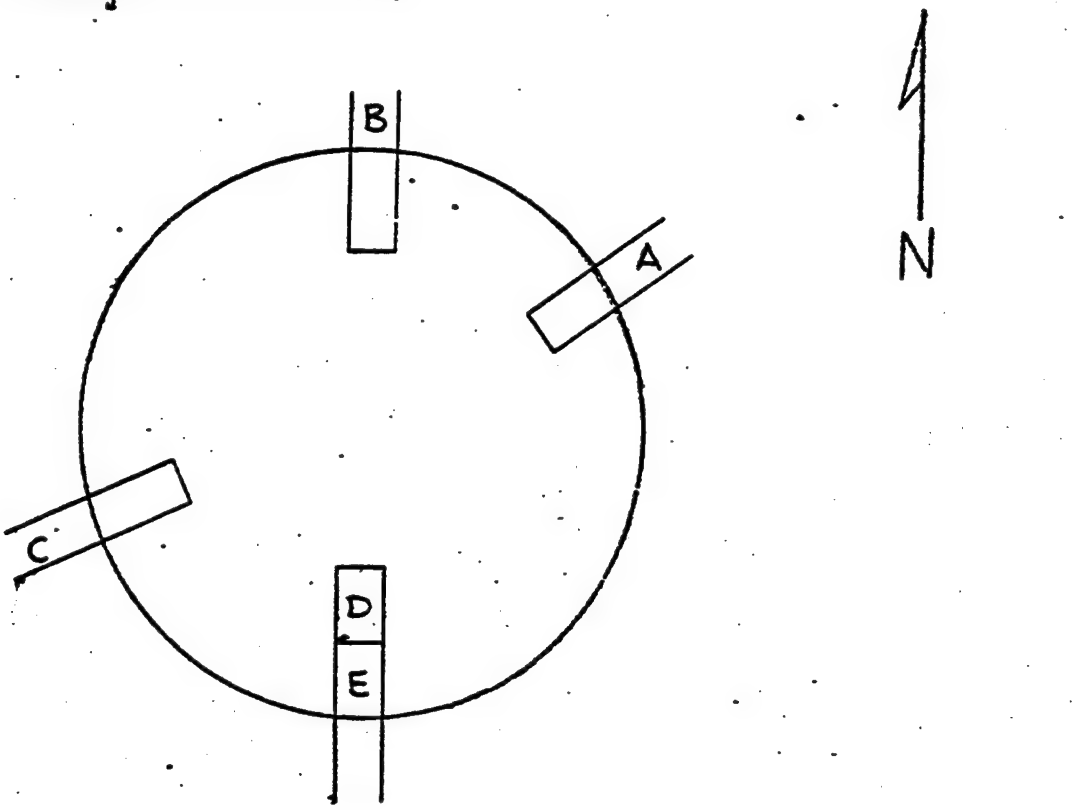
Line	Size	Mat'l	Depth*	Service
A	6"	TILE	3'-0"	OUTLET TO W-6B
B	6"	TILE	3'-0"	FROM BLDG 515 EXT. SUMP
C				
D				
E				
F				

* From Top Ring

Manhole Number W 7

Approximate Depth* 9'-6"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-333'-6" W-1634'-0"

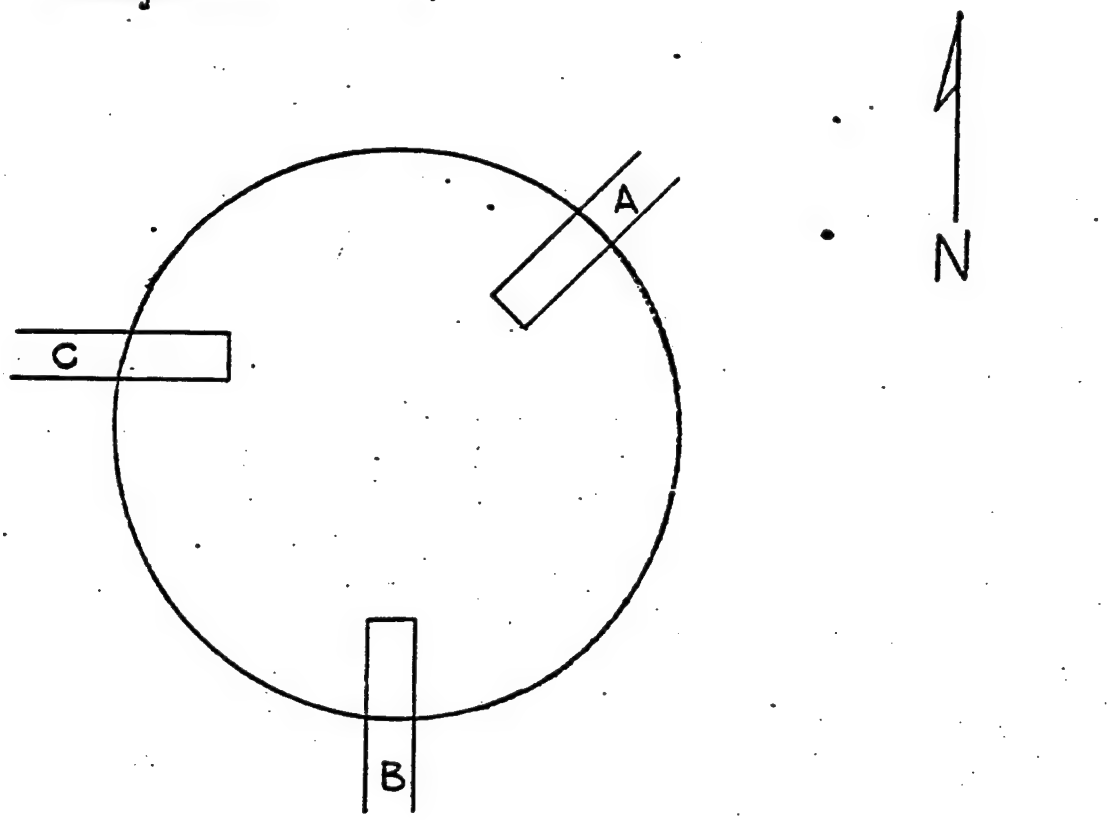
Line	Size	Mat'l	Depth *	Service
A	12"			ABANDON
B	12"	TILE	9'-6"	OUTLET TO W-1
C	12"	TILE	9'-6"	INLET FROM W-8
D	10"	TILE	9'-1"	INLET FROM W-12
E	10"	TILE	5'-10"	BLDG SIZ SUMP, & AIR WASH
F				

* From Top Ring

Manhole Number W8

Approximate Depth* 8'-5"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-299'-6" W-1698'-6"

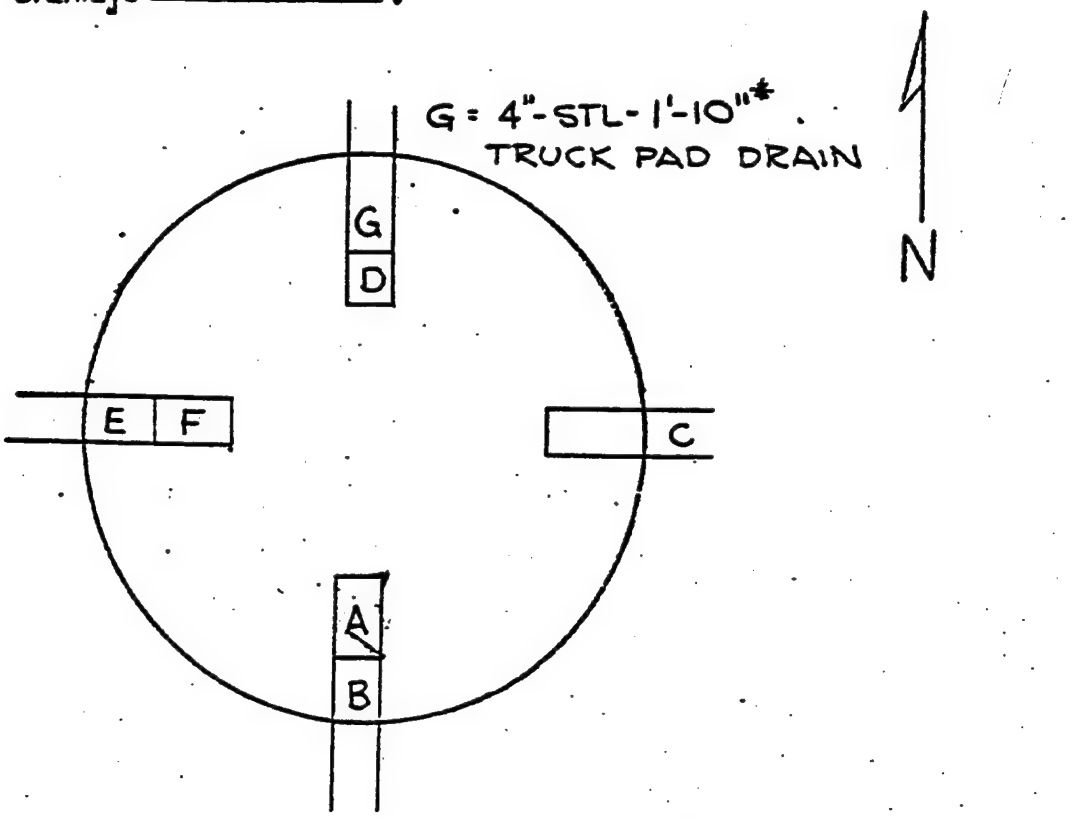
Line	Size	Mat'l	Depth *	Service
A	12"	TILE	8'-5"	OUTLET TO W-7
B	12"	TILE	8'-5"	INLET FROM W-9
C	1½"	STL	1'-10"	BLDG 511 EAST SUMP
D				
E				
F				

* From Top Ring

Manhole Number W 9

Approximate Depth* 8'-1"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-218'-0" W-1698'-6"

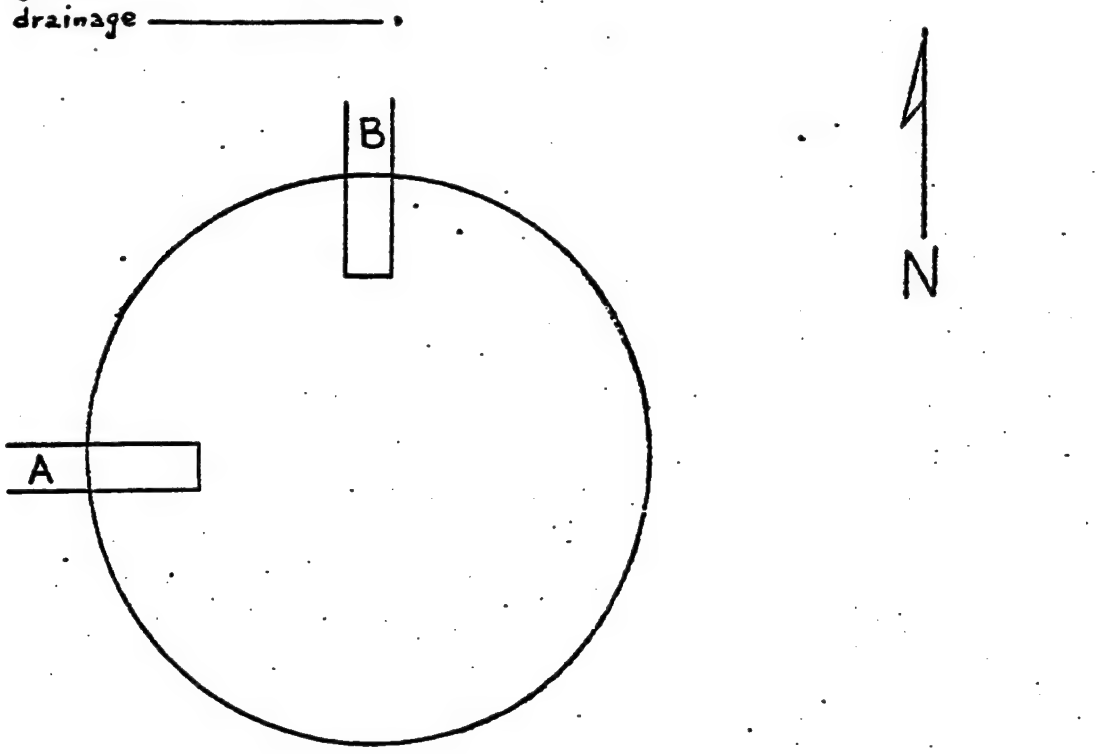
Line	Size	Mat'l	Depth*	Service
A	12"	TILE	8'-1"	INLET FROM W-10
B	4"	STL	1'-10"	FROM 515 TANK FARM & BLDG 515, V-1184
C	10"	TILE	7'-8"	INLET FROM W-13
D	12"	TILE	8'-1"	OUTLET TO W-8
E	3"	STL	1'-10"	ABANDON
F	10"	TILE	8'-1"	BLDG 515 SUMP

* From Top Ring

Manhole Number W 10

Approximate Depth* 6'-9"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N 158'-6" W-1698'-6"

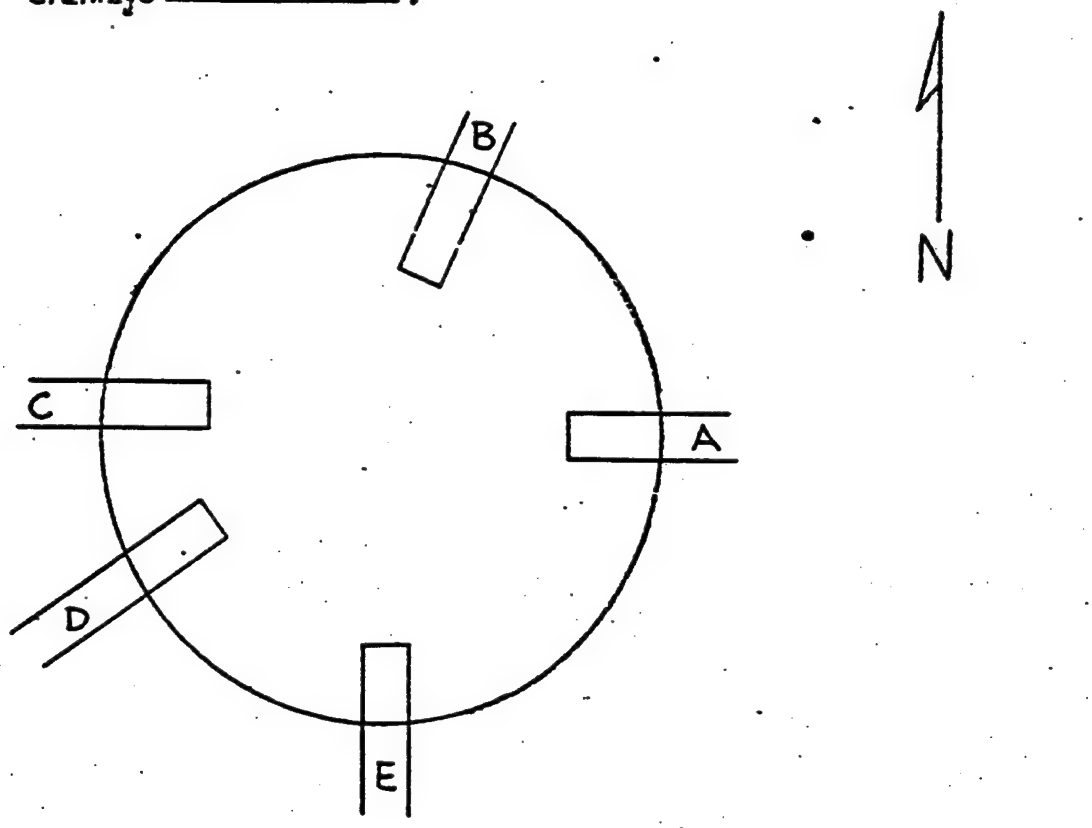
Line	Size	Mat'l	Depth*	Service
A	12"	TILE	5'-10"	INLET FROM W-11
B	12"	TILE	6'-9"	OUTLET TO W-9
C				
D				
E				
F				

* From Top Ring

Manhole Number W 11

Approximate Depth* 8'-2"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-158'-6" W-1742'-6"

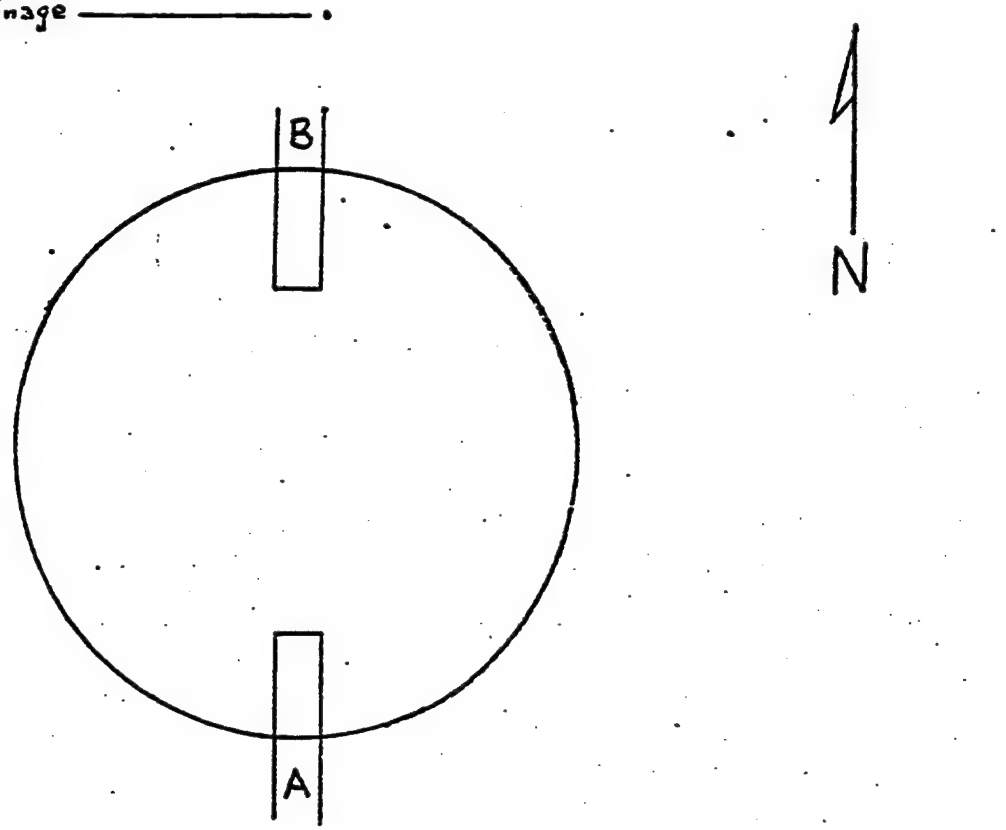
Line	Size	Mat'l	Depth *	Service
A	12"	TILE	8'-2"	OUTLET TO W-10
B	12"	TILE	8'-2"	ABANDON
C	1"	STL	1'-0"	ABANDON
D	12"	TILE	8'-2"	ABANDON
E	4"	TILE	3'-10"	FROM BLDG 515A
F				

* From Top Ring

Manhole Number W 12

Approximate Depth* 6'-2"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-313'-6" W-1627'-0"

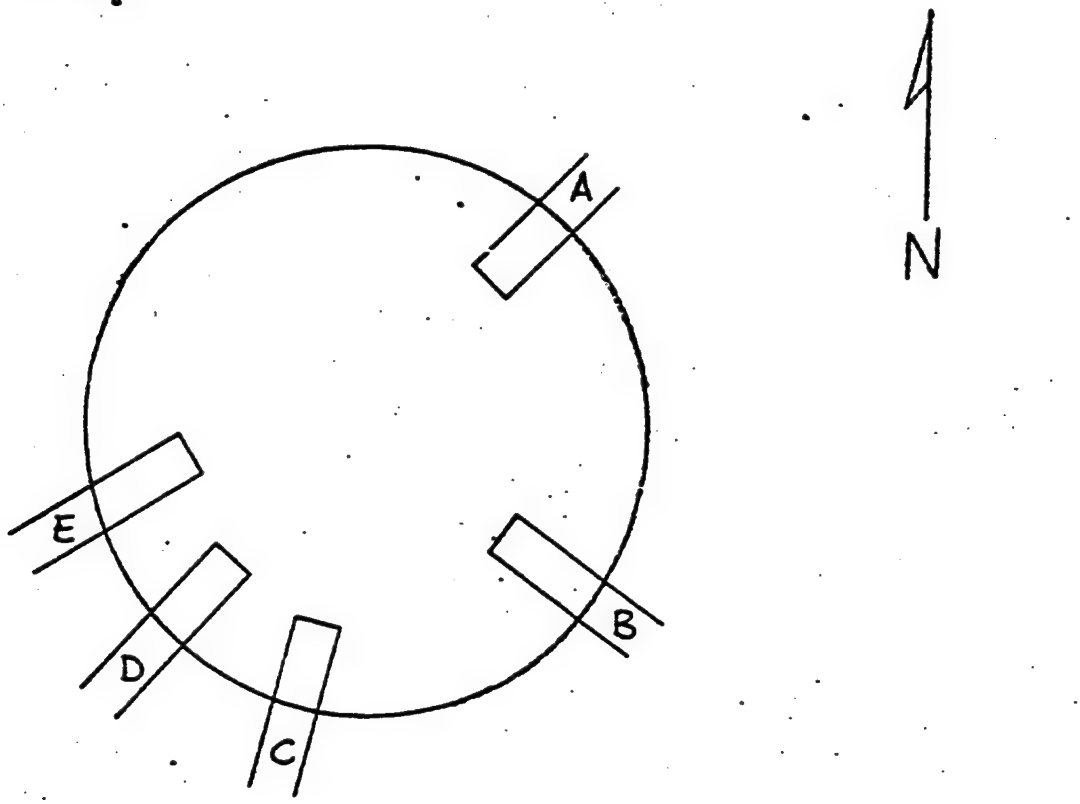
Line	Size	Mat'l	Depth *	Service
A	10"	TILE	6'-0"	INLET FROM W-15
B	10"	TILE	6'-2"	OUTLET TO W-7
C				
D				
E				
F				

* From Top Ring

Manhole Number W 13

Approximate Depth* 3'-4"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-218'-9" W-1392'-10"

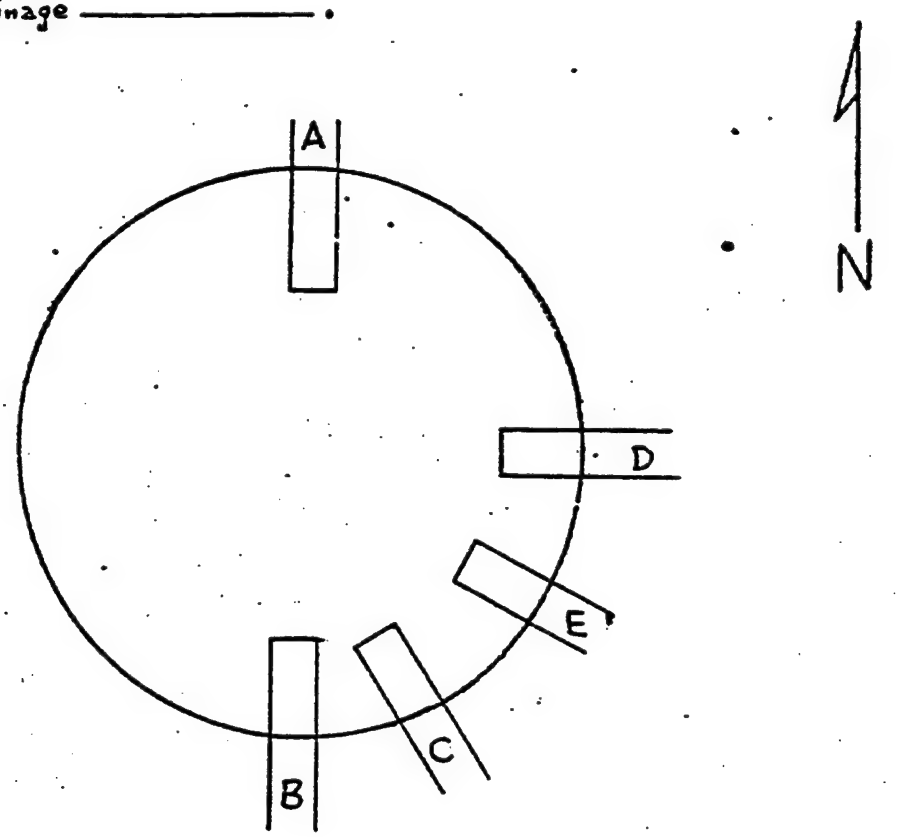
Line	Size	Mat'l	Depth *	Service
A	6"	TILE	2'-6"	BLDG 514 SCRUBBER
B	6"	TILE	2'-6"	BLDG 514 SCRUBBER
C	2"	STL	1'-7"	T27 PAD DRAIN
D	4"	STL	1'-2"	TRUCK LOADING PAD
E	8"	TILE	3'-4"	OUTLET TO W-9
F				

* From Top Ring

Manhole Number W 15

Approximate Depth* 7'-3"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-166'-6" W-1646'-6"

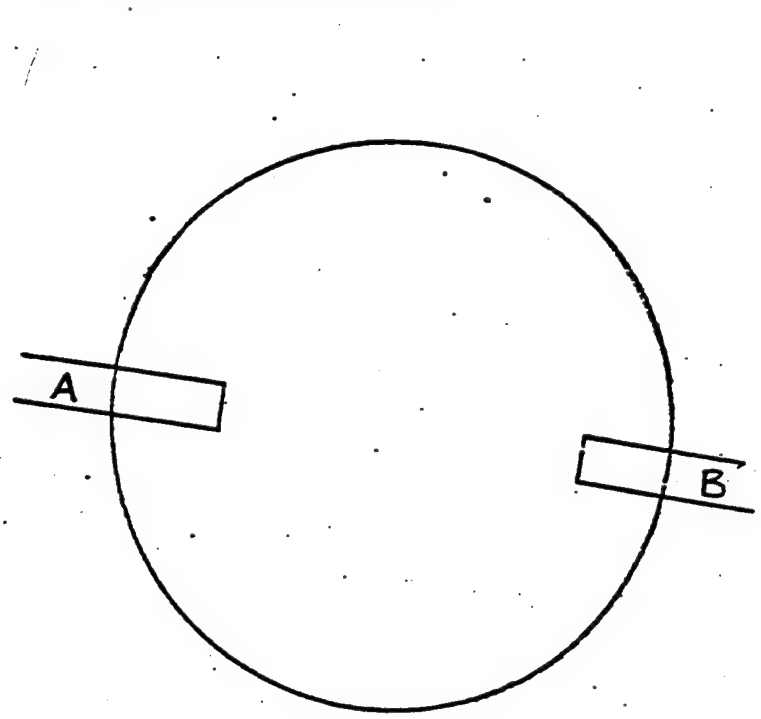
Line	Size	Mat'l	Depth*	Service
A	12"	TILE	7'-3"	OUTLET TO W-12
B	12"	TILE	6'-3"	INLET FROM W-16
C	4"	TILE	1'-10"	BLDG 517 LAB
D	4"	TILE	4'-0"	BLDG 517 LAB
E	2"	STL	2'-1"	BLDG 517 LAB
F				

* From Top Ring

Manhole Number W 17

Approximate Depth* 4'-3"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-2'-6" W-1750'-0"

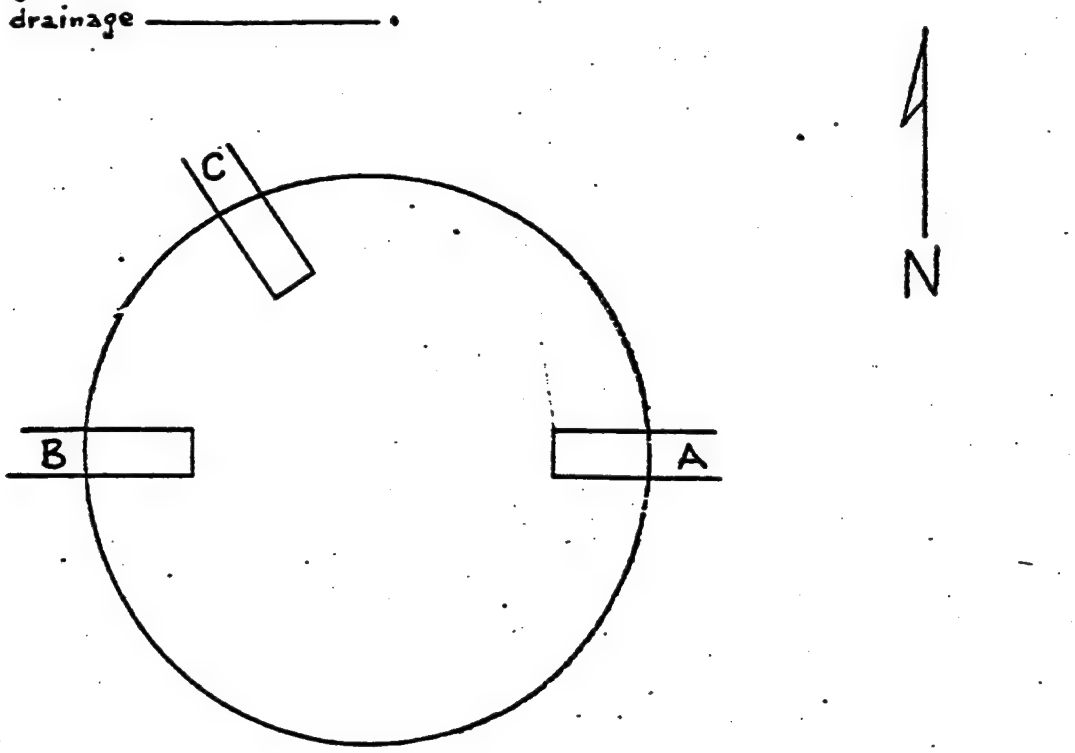
Line	Size	Mat'l	Depth *	Service
A	6"	TILE	4'-3"	INLET FROM W-18
B	6"	TILE	4'-3"	OUTLET TO W-21
C				
D				
E				
F				

* From Top Ring

Manhole Number W 18

Approximate Depth* 2'-10"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-12'-6" W-1934'-0"

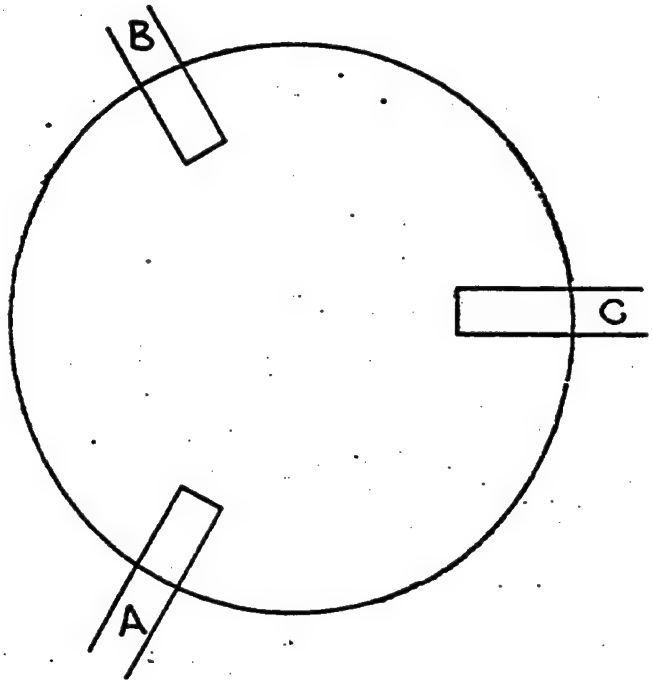
Line	Size	Mat'l	Depth*	Service
A	6"	TILE	2'-10"	OUTLET TO W-17
B	6"	TILE	2'-10"	INLET FROM W-19
C	4"	TILE	2'-4"	INLET FROM BLDG 515 EXT. SUMP
D				
E				
F				

* From Top Ring

Manhole Number W19

Approximate Depth* 4'-0"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-30'-6" W-2111'-0"

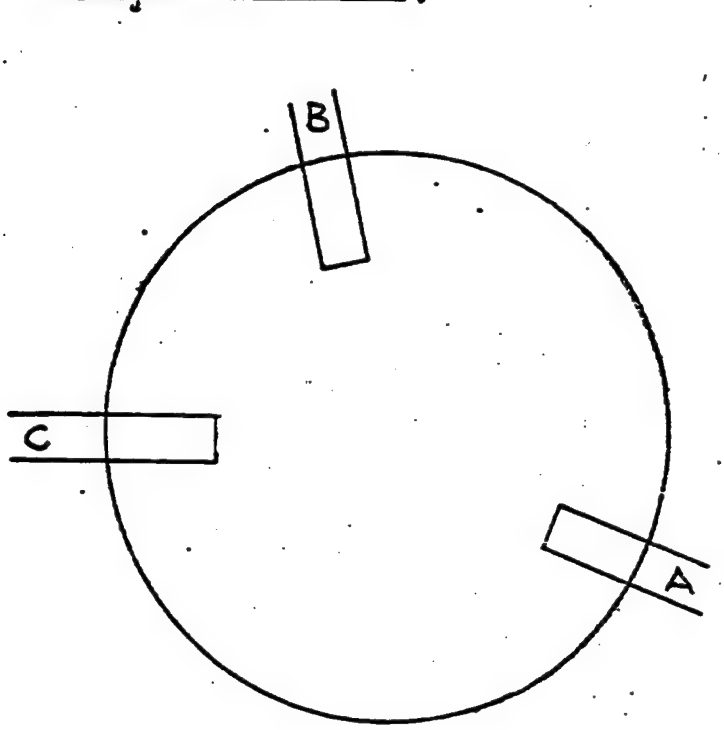
Line	Size	Mat'l	Depth *	Service
A	8"	TILE	3'-0"	ABANDON
B	6"	TILE	3'-6"	ABANDON
C	6"	TILE	4'-0"	OUT LET TO W-18
D				
E				
F				

* From Top Ring

Manhole Number W21

Approximate Depth* 7'-9"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location S-23'-6" W-1606'-6"

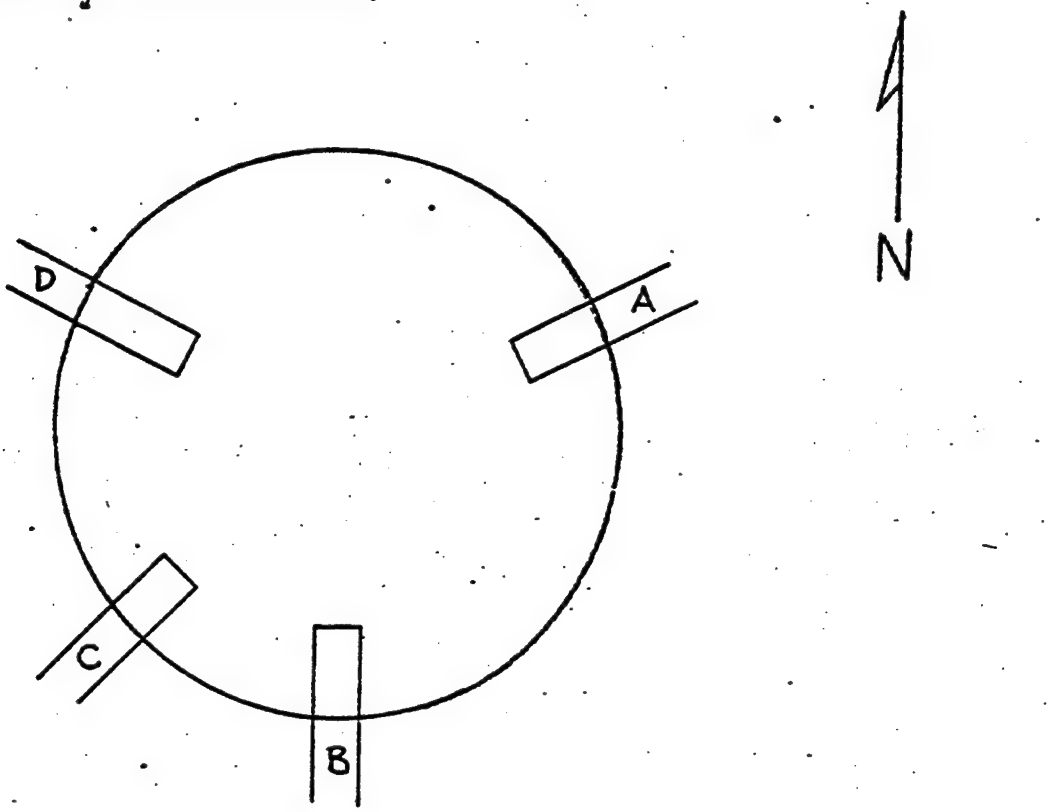
Line	Size	Mat'l	Depth *	Service
A	12"	TILE	7'-9"	INLET FROM W-22
B	12"	TILE	7'-9"	OUTLET TO W-16
C	6"	TILE	7'-3"	INLET FROM W-17
D				
E				
F				

* From Top Ring

Manhole Number W 22

Approximate Depth* 8'-6"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location S-45'-3" W-1511'-6"

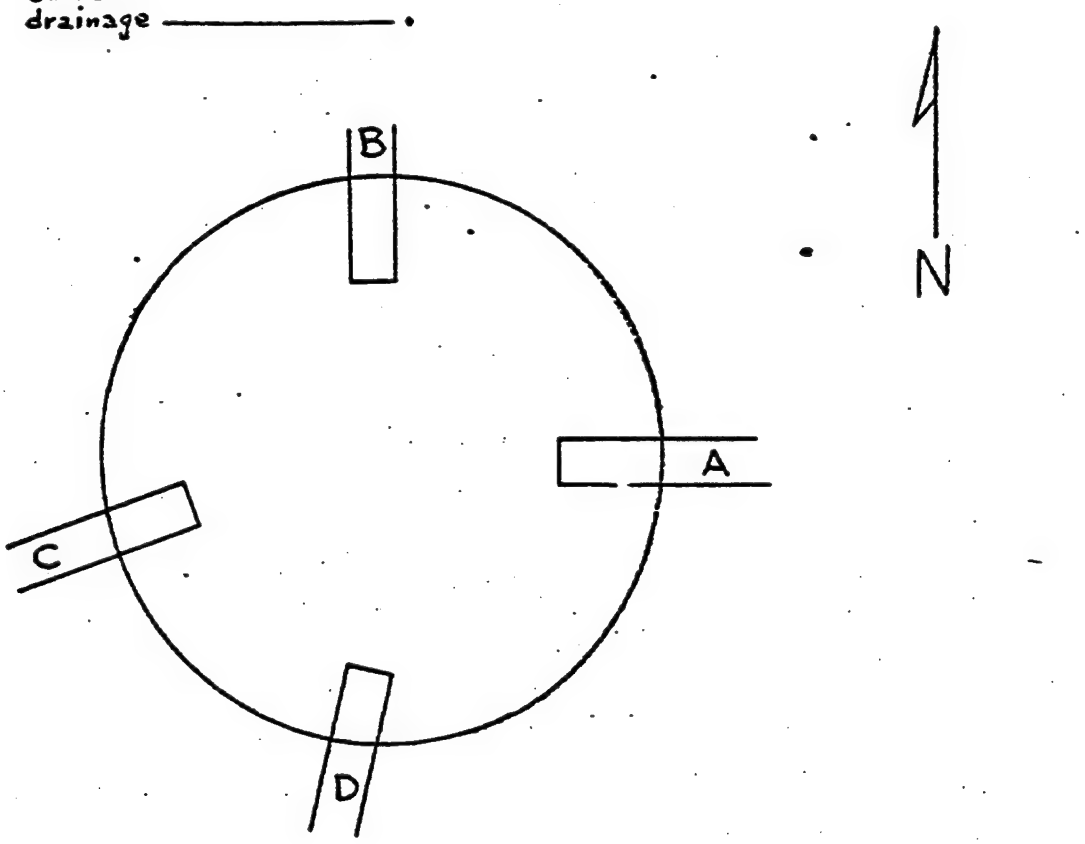
Line	Size	Mat'l	Depth *	Service
A	12"	TILE	8'-6"	INLET FROM W-23
B	10"	TILE	8'-6"	INLET FROM W-25
C	8"	TILE	4'-0"	FROM BLDG 523
D	12"	TILE	8'-6"	OUTLET TO W-21
E				
F				

* From Top Ring

Manhole Number W 23

Approximate Depth* 3'-7"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-9'-9" W-1379'-2"

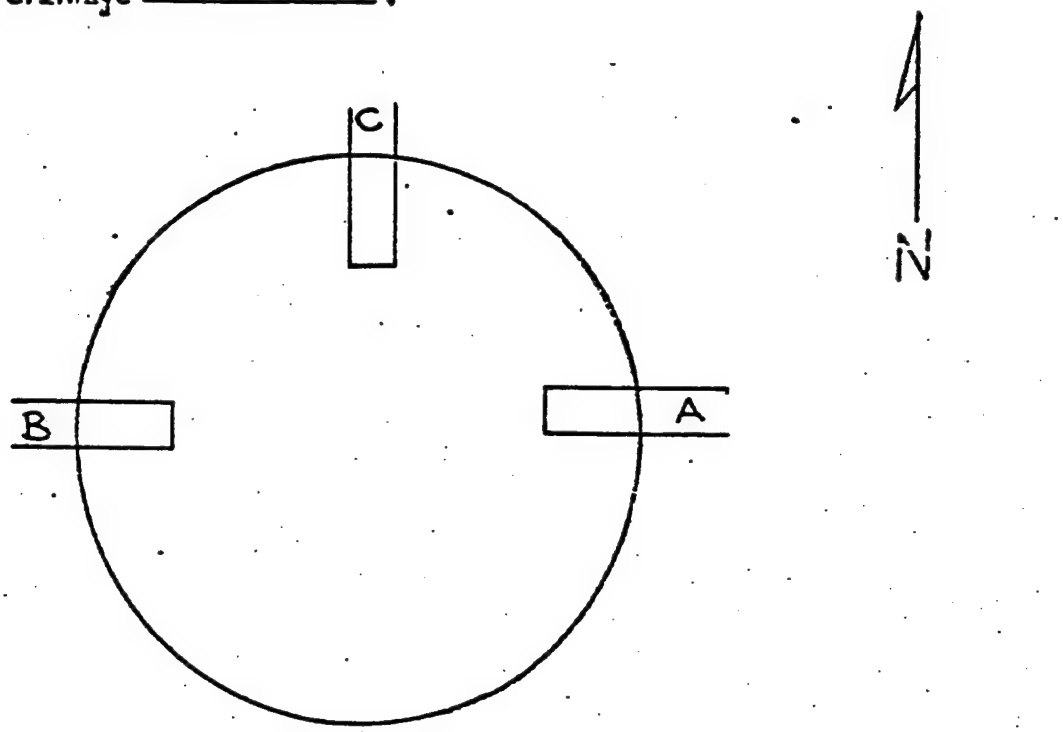
Line	Size	Mat'l	Depth *	Service
A	10"	TILE	3'-7"	INLET W-24, BLDG 525
B	6"	TILE	3'-7"	BLDG 525
C	12"	TILE	3'-7"	OUTLET TO W-22
D	8"	TILE	3'-3"	ABANDON
E				
F				

* From Top Ring

Manhole Number W24

Approximate Depth* 3'-3"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location N-8'-6" W-1218'-10"

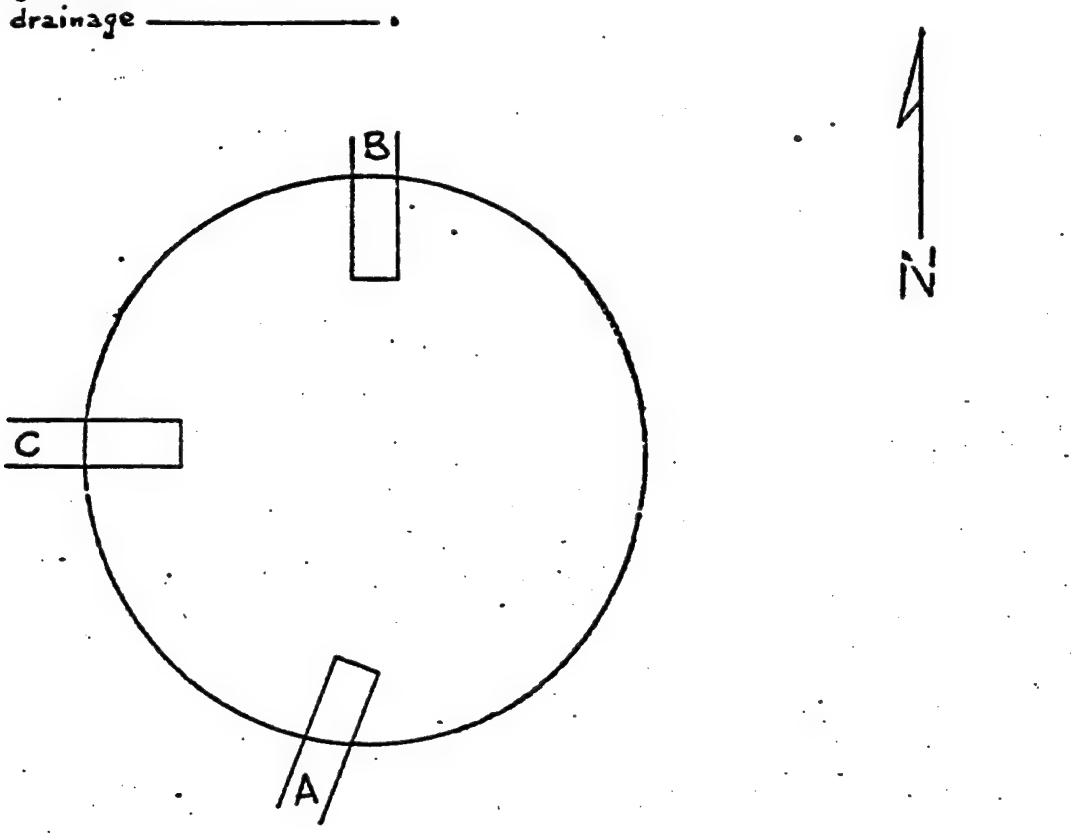
Line	Size	Mat'l	Depth*	Service
A	4"	TILE	2'-2"	ABANDON
B	8"	TILE	3'-3"	OUTLET TO W-23
C	6"	TILE	3'-1"	BLDG 521
D				
E				
F				

* From Top Ring

Manhole Number W 25

Approximate Depth* 7'-0"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location S-174'-6" W-1511'-6"

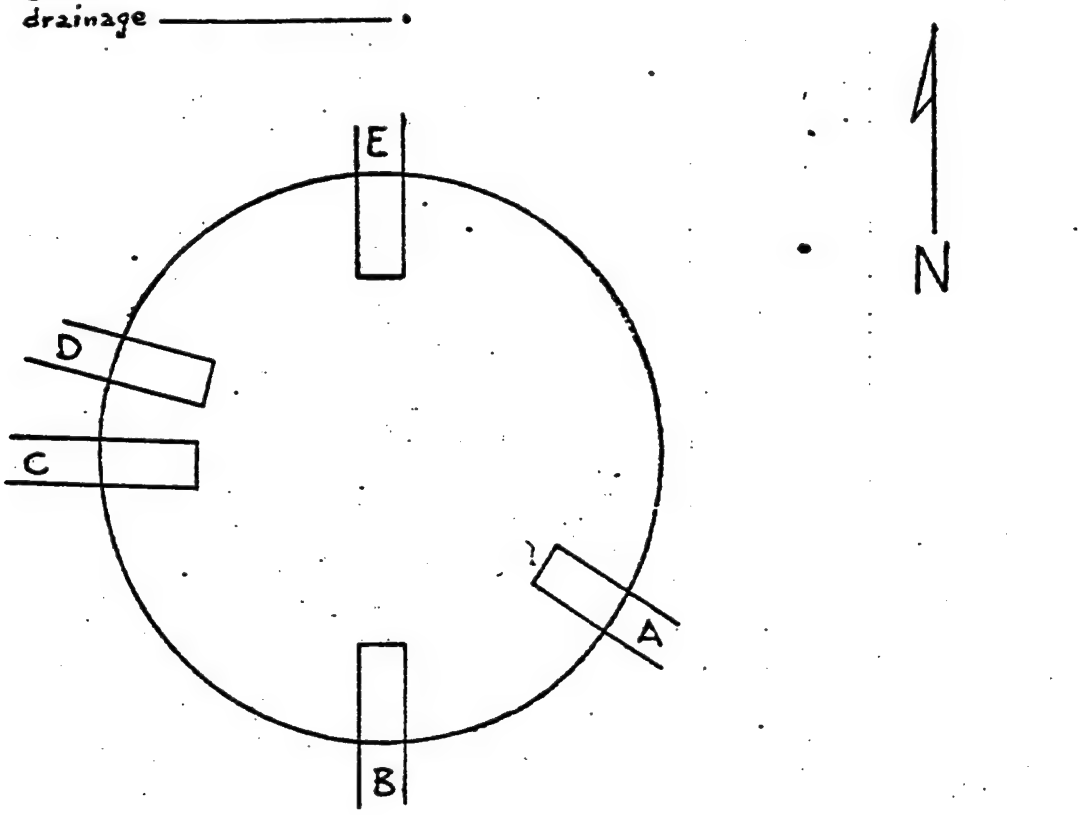
Line	Size	Mat'l	Depth *	Service
A	10"	TILE	7'-0"	INLET FROM W-26
B	10"	TILE	7'-0"	OUTLET TO W-22
C	8"	TILE	4'-10"	ABANDON
D				
E				
F				

* From Top Ring

Manhole Number W26

Approximate Depth* 8'-6"

System: contaminated sewer VE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location S-244'-6" W-1539'-0"

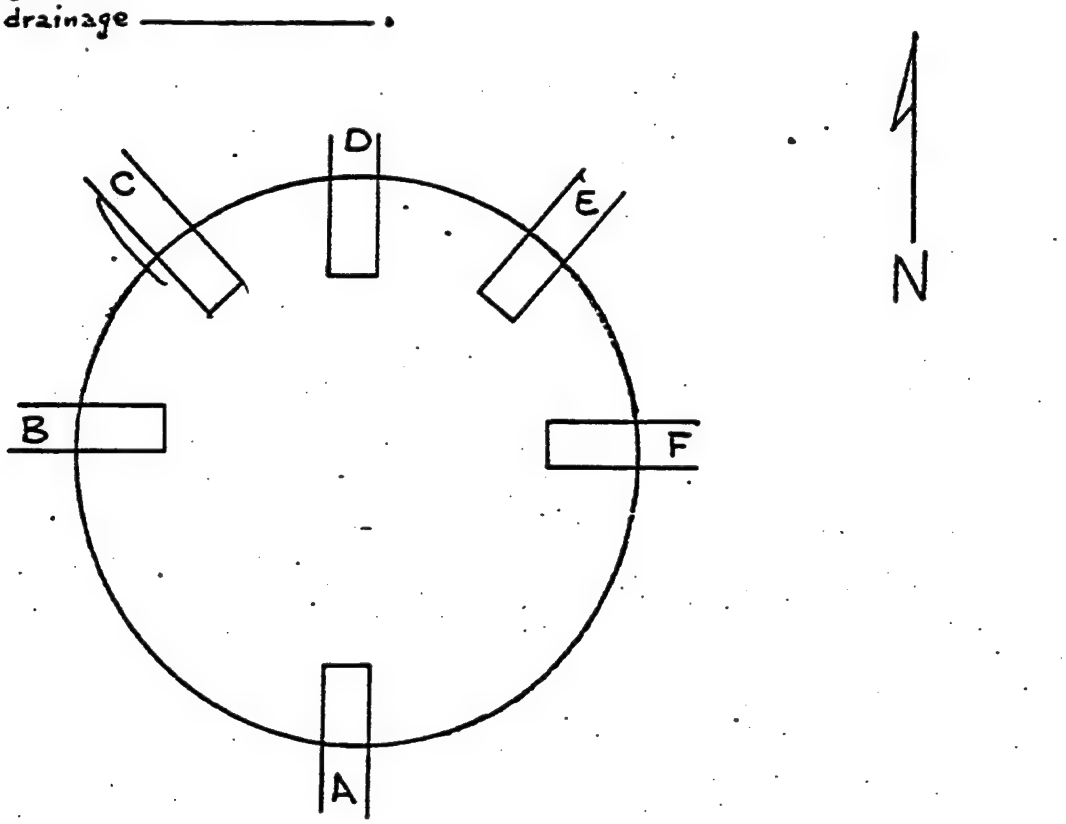
Line	Size	Mat'l	Depth*	Service
A	6"	STL	8'-0"	BLDG 451 & TRUCK PAD
B	10"	TILE	8'-6"	INLET FROM W-27
C	6"	TILE	4'-8"	ABANDON
D	6"	TILE	4'-8"	ABANDON
E	10"	TILE	8'-6"	OUTLET TO W-25
F				

* From Top Ring

Manhole Number W-27

Approximate Depth* 6'-0"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location S-458'-3" W-1539'-0"

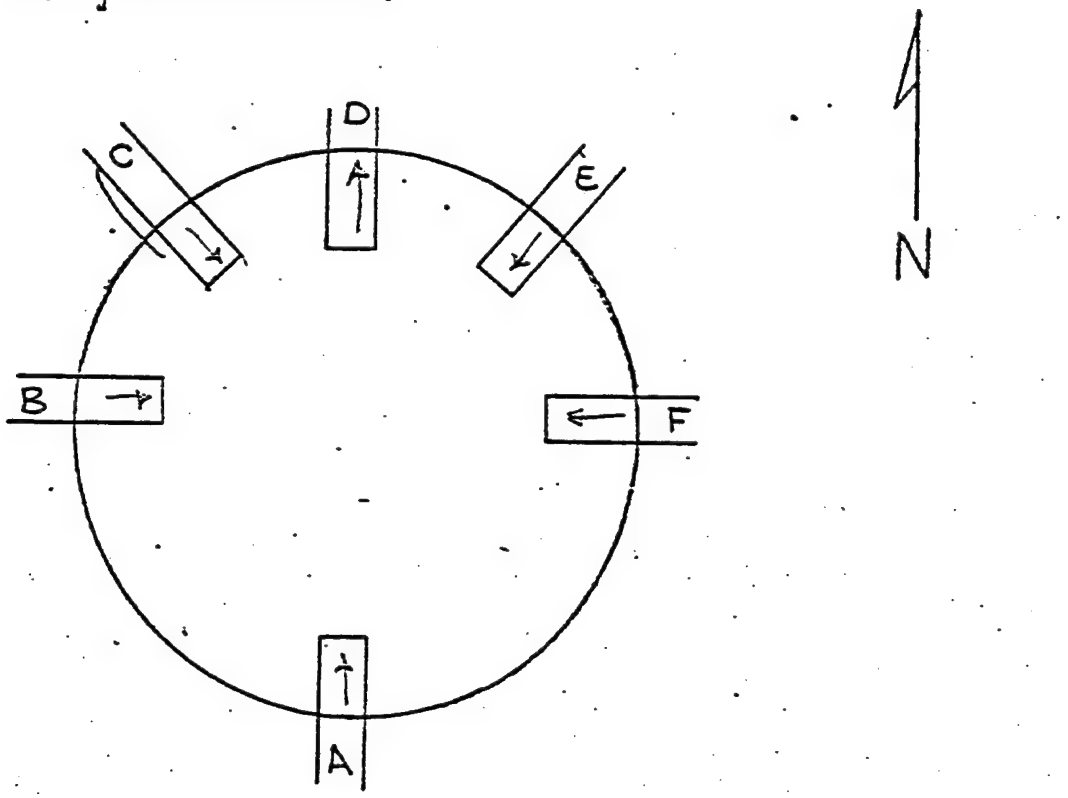
Line	Size	Mat'l	Depth*	Service
A	10"	TILE	6'-0"	INLET FROM W-28
B	4"	TILE	3'-3"	BLDG 422 SUMPS
C	4"	TILE	3'-3"	BLDG 422 FLOOR DRAINS
D	10"	TILE	6'-0"	OUTLET TO W-26
E	4"	TILE	4'-6"	BLDG 424A SUMP
F	12"	TILE	6'-0"	INLET FROM W-31

* From Top Ring

Manhole Number W-27

Approximate Depth* 6'-0"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location S-458'-3" W-1539'-0"

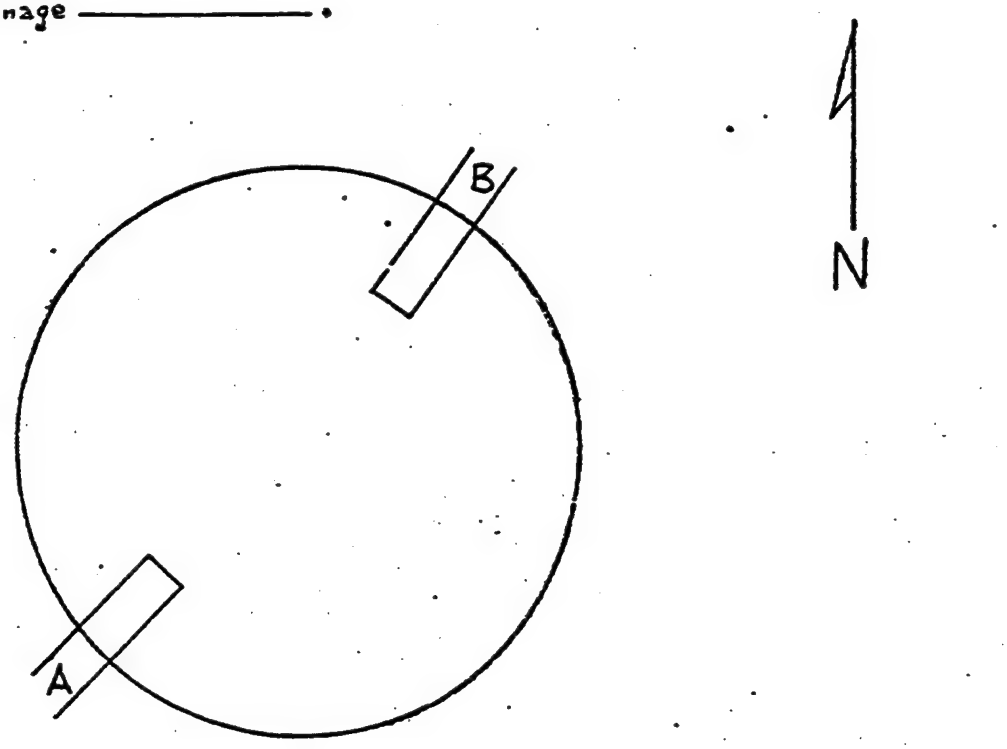
Line	Size	Mat'l	Depth*	Service
A	10"	TILE	6'-0"	INLET FROM W-28
B	4"	TILE	3'-3"	BLDG 422 SUMPS
C	4"	TILE	3'-3"	BLDG 422 FLOOR DRAINS
D	10"	TILE	6'-0"	OUTLET TO W-26
E	4"	TILE	4'-6"	BLDG 424A SUMP
F	12"	TILE	6'-0"	INLET FROM W-31

* From Top Ring

Manhole Number W 28

Approximate Depth* 6'-6"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location S-587'-6" W-1539'-0"

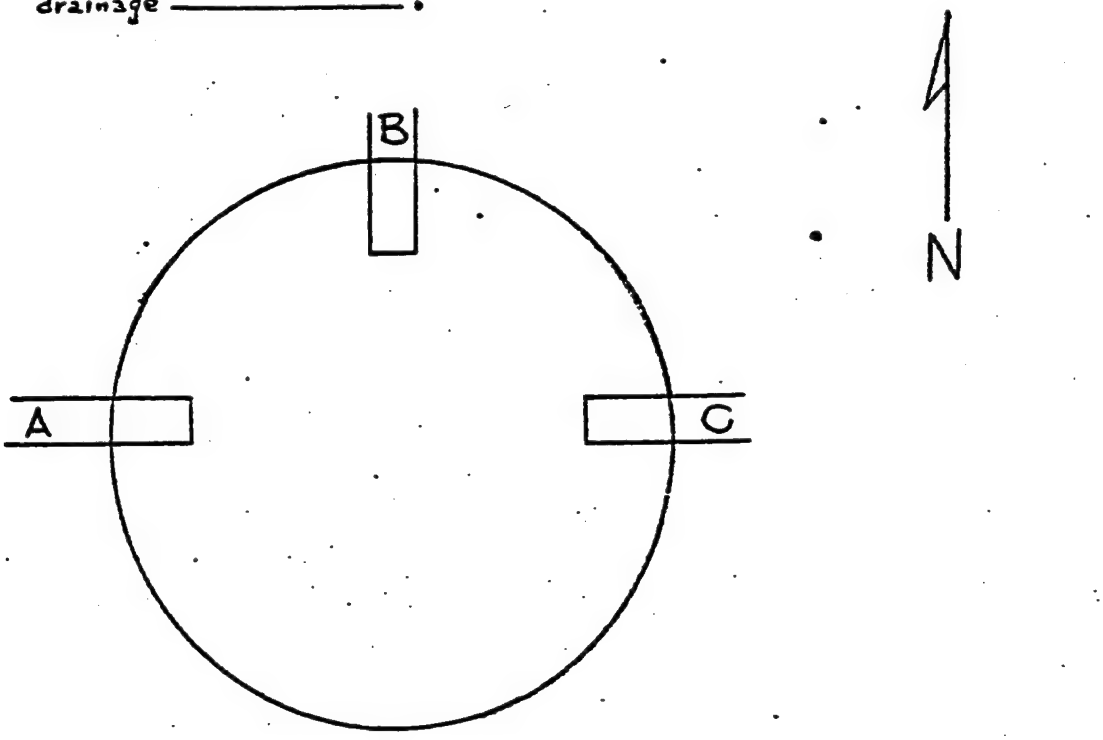
Line	Size	Mat'l	Depth*	Service
A	10"	TILE	6'-6"	INLET FROM W-29
B	10"	TILE	6'-6"	OUTLET TO W-27
C				
D				
E				
F				

* From Top Ring

Manhole Number W29

Approximate Depth* 4'-3"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location S-592'-6" W-1739'-0"

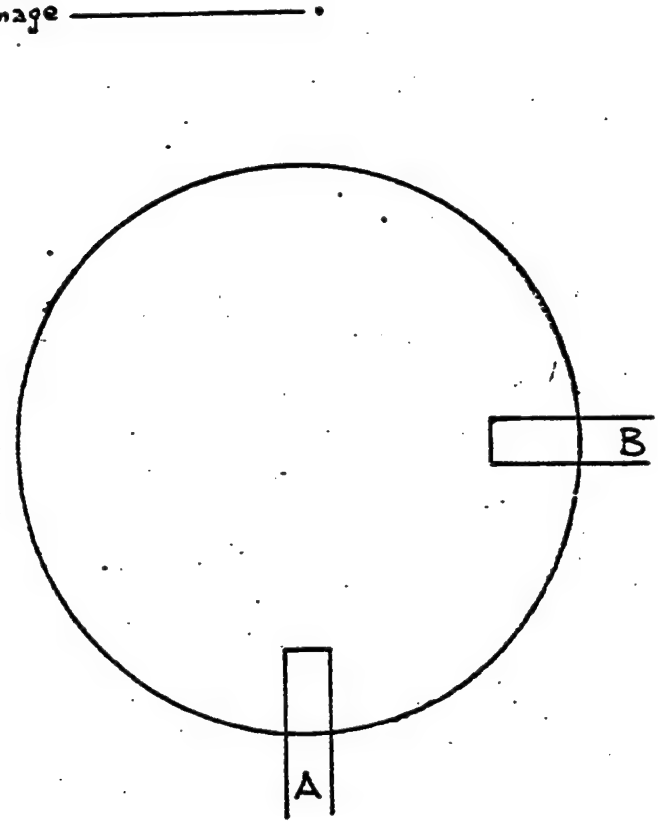
Line	Size	Mat'l	Depth *	Service
A	10"	TILE	4'-3"	INLET FROM W-30
B	8"	CONC	3'-6"	
C	10"	TILE	4'-3"	OUTLET TO W-28
D				
E				
F				

* From Top Ring

Manhole Number W30

Approximate Depth* 3'-9"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____; surface drainage _____.



Location S-636'-6" W-1831'-0"

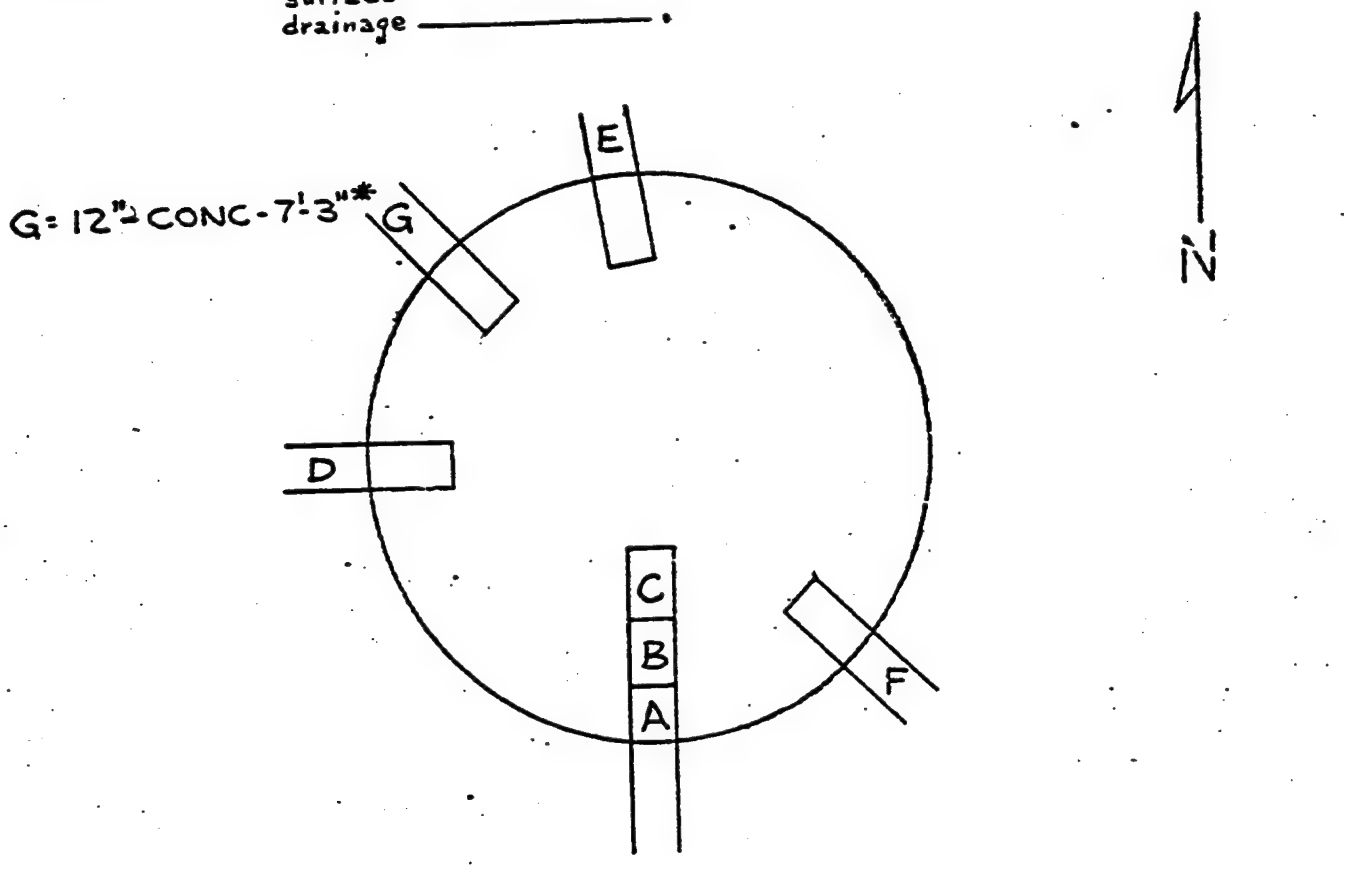
Line	Size	Mat'l	Depth*	Service
A	4"	TILE	3'-9"	BLDG 432 SUMP
B	6"	TILE	3'-9"	OUTLET TO W-29
C				
D				
E				
F				

* From Top Ring

Manhole Number W31

Approximate Depth* 7'-3"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location S-458'-3" W-1376'-0"

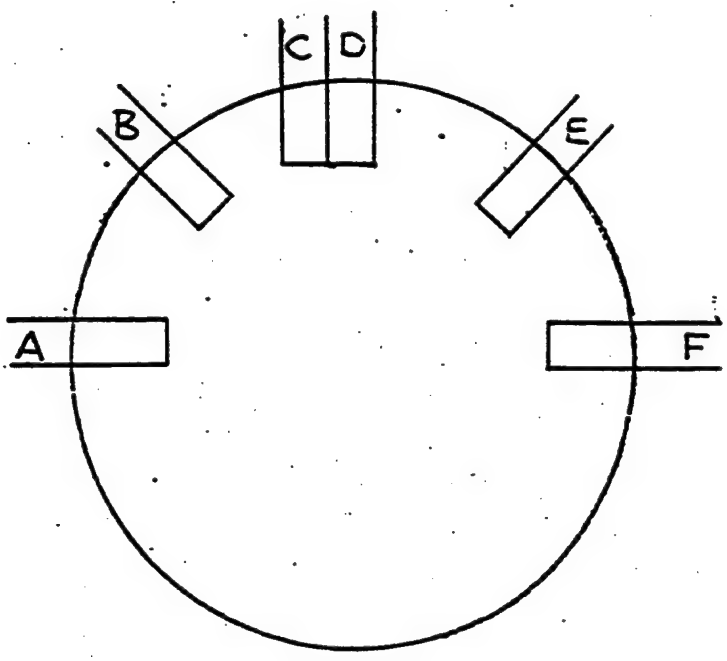
Line	Size	Mat'l	Depth*	Service
A	3"	STL	2'-0"	PAD DRAIN
B	4"	STL	2'-7"	SUMP DRAIN
C	12"	TILE	7'-3"	INLET FROM W-34
D	4"	STL	4'-9"	INLET FROM W-36
E	6"	STL	3'-9"	SUMP DRAIN
F	10"	CONC	6'-0"	INLET FROM W-32

* From Top Ring

Manhole Number W32

Approximate Depth* 5'-0"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location S-474'-3" W-1310'-0"

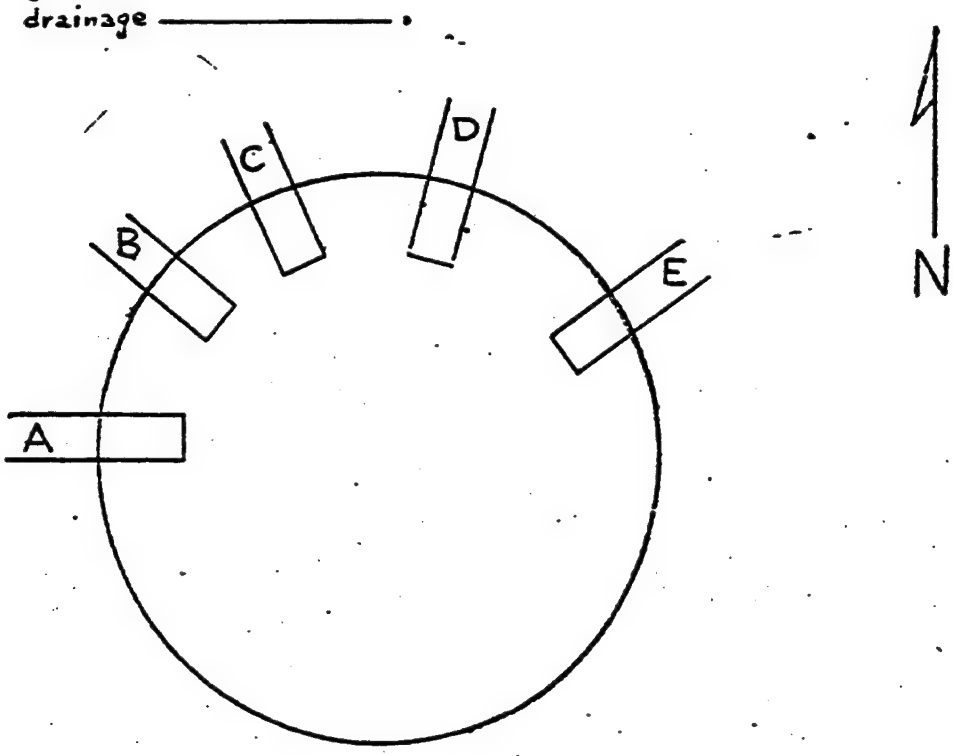
Line	Size	Mat'l	Depth*	Service
A	10"	CONC	5'-0"	OUTLET TO W-31
B	8"	CONC	4'-6"	BLDG 473
C	1½"	STL	4'-6"	BLDG 471
D	4"	CONC	4'-6"	BLDG 471
E	6"	CONC	2'-4"	BLDG 471
F	8"	CONC	4'-9"	INLET FROM W-33

* From Top Ring

Manhole Number W 33

Approximate Depth* 3'-4"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location S-474'-3" W-1249'-0"

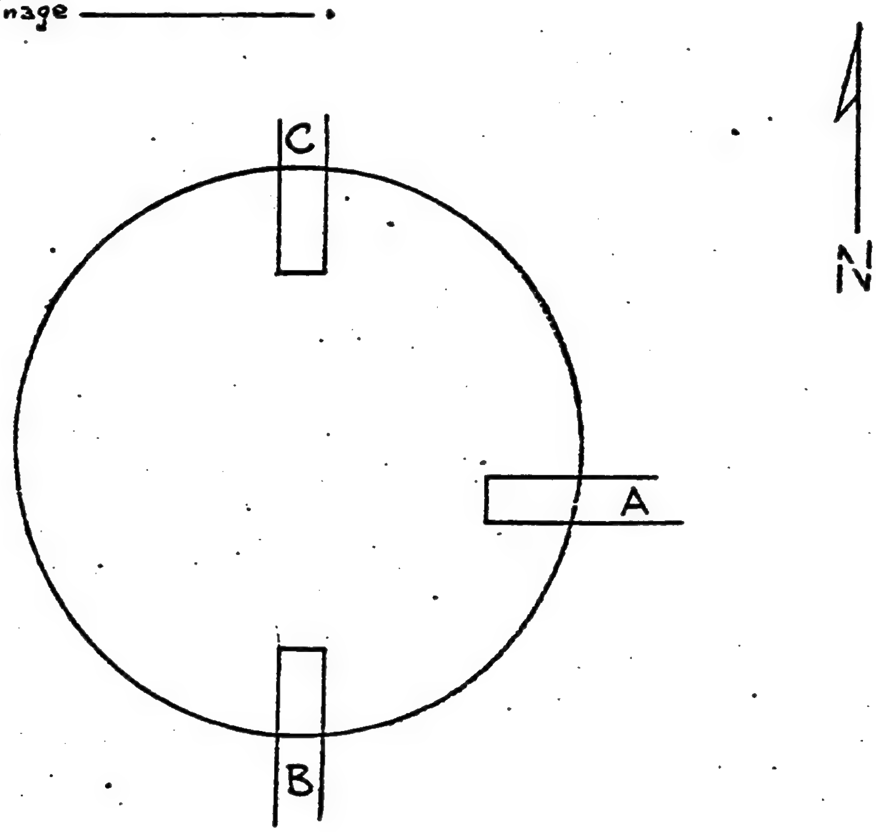
Line	Size	Mat'l	Depth*	Service
A	8"	TILE	3'-4"	OUTLET TO W-32
B	4 6"	~~CONC~~	1'-10"	BLDG 471
C	3"	STL	2'-4"	BLDG 471
D	6"	CONC	3'-2"	ABANDON
E	4"	STL	2'-4"	T-132 PAD DRAIN
F				

* From Top Ring

Manhole Number W 34

Approximate Depth* 4'-0"

System: contaminated sewer YE-13347, sanitary sewer ________, P.W.R. ________, surface drainage ________.



Location S-524'-0" W-1365'-6"

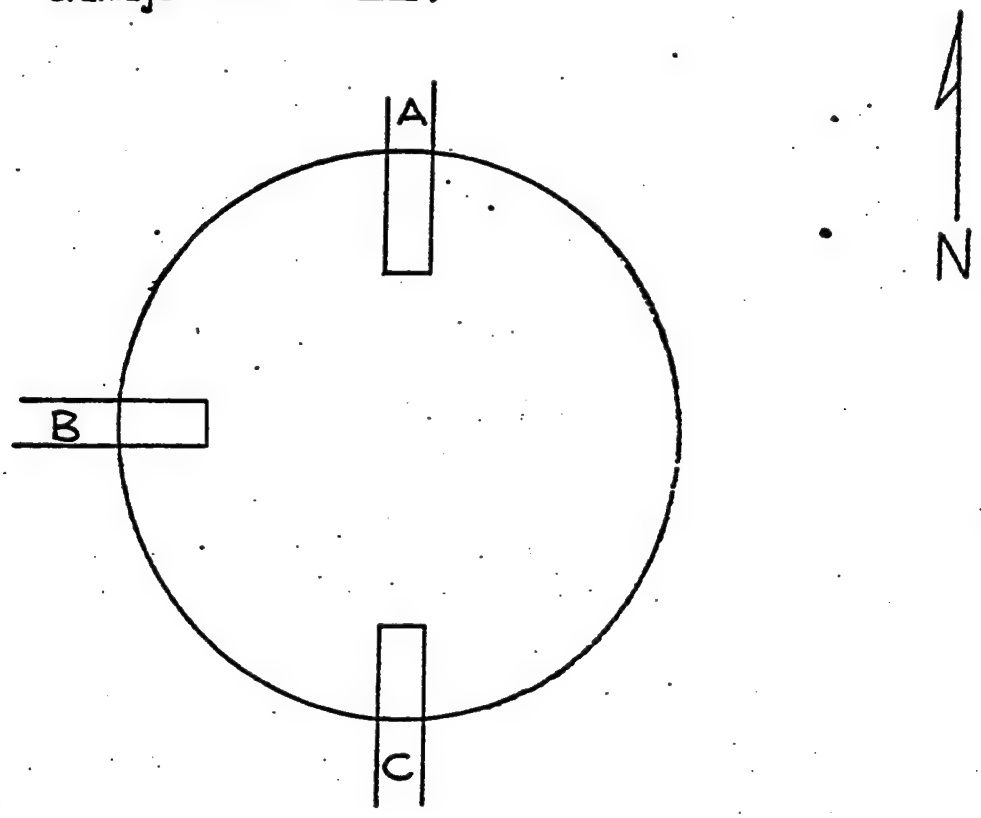
Line	Size	Mat'l	Depth*	Service
A	8"	TILE	4'-0"	~~OUTLET TO W-37~~ INLET FROM W-35
B	8"	TILE	4'-0"	ABANDON
C	12"	TILE	4'-0"	OUTLET TO W-31
D				
E				
F				

* From Top Ring

Manhole Number W 35

Approximate Depth* 3'-10"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location S-528'-3 W 1171'-0"

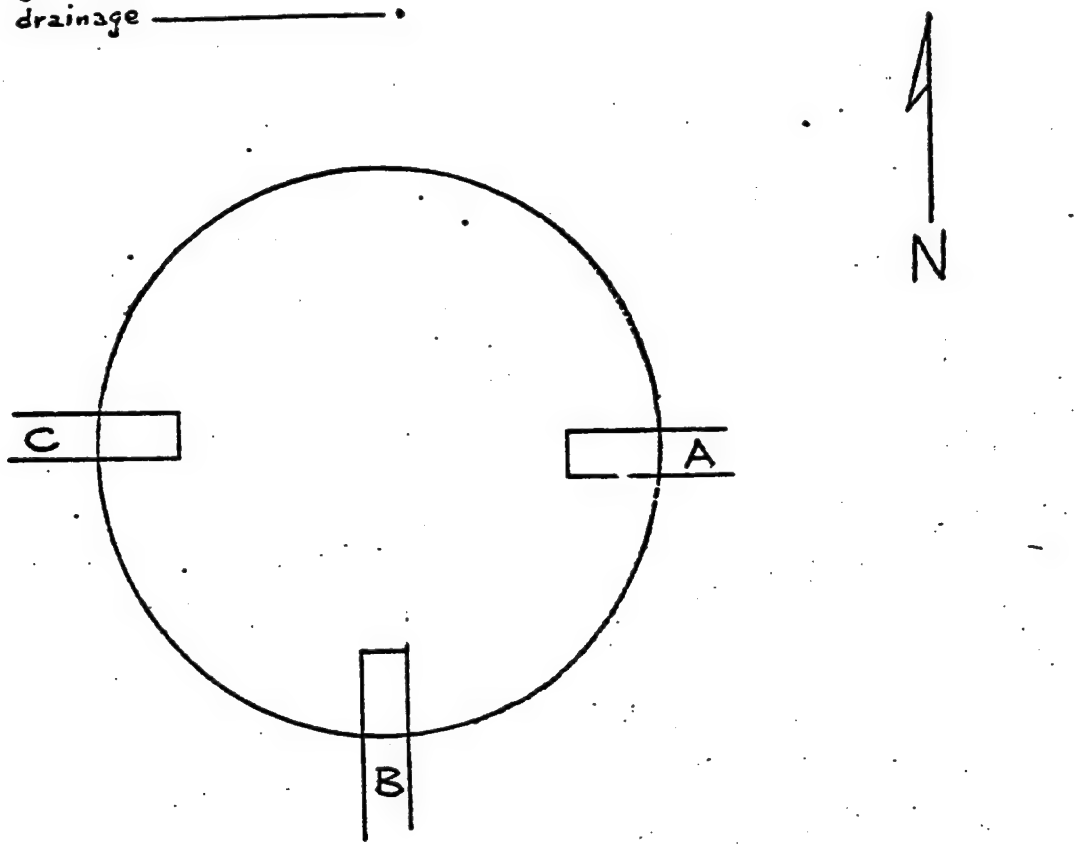
Line	Size	Mat'l	Depth *	Service
A	8"	TILE	3'-10"	BLDG 471C
B	8"	TILE	3'-10"	OUTLET TO W-34
C	2"	PLASTIC	10"	472 TANK FARM SUMP
D				
E				
F				

* From Top Ring

Manhole Number W 36

Approximate Depth* 4'-6"

System: contaminated sewer YE-13347, sanitary sewer _____, P.W.R. _____, surface drainage _____.



Location S-438'-3" W-1460'-0"

Line	Size	Mat'l	Depth*	Service
A	4"	STL	1'-7"	OUTLET TO W-31
B	4"	STL	1'-7"	AREA DRAIN
C	4"	STL	1'-7"	AREA DRAIN
D				
E				
F				

* From Top Ring

APPENDIX B

LOW PRESSURE AIR TESTING STANDARD OPERATING PROCEDURE

JET CLEANING AND TV INSPECTION STANDARD OPERATING PROCEDURE

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to document the required procedures for air testing sewer lines at RMA. Low pressure air testing of sewer lines is an accepted technique for demonstrating the relative structural integrity of newly installed vitrified clay pipe lines. It is recognized that due to the age of the original RMA sewers (40 plus years) and the severe service conditions, the low pressure air test is a preliminary test that will hopefully provide information that will assist the investigators in refining the selection of specific sewer excavation sites. In this context, the low pressure air test is one of several techniques used to determine excavation site locations, and it is not considered in itself an adequate indicator of the sewers' structural integrity.

2.0 REFERENCE

2.1 ASTM C 828-80: Low-Pressure Air Test of Vitrified Clay Pipe Lines

2.2 Standard Task Operating Procedures, MKE Health and Safety Plan

3.0 DEFINITIONS AND RESPONSIBILITIES

3.1 Subcontractor - Guildner Pipeline Maintenance, Inc.

3.2 Health and Safety Supervisor - John Schmerber

3.3 Task Manager - Alan Notary

3.4 Decontamination Support - MKE personnel, as needed

4.0 PROCEDURE

4.1 The following procedure is subsequent to the standard health and safety procedures to be followed during the approach, monitoring and entry of manholes at RMA.

4.2 Insert inflatable rubber plugs of appropriate size into both ends of the section of sewer pipe to be tested. Take care to clean the pipe invert of any debris that could prevent the plug from seating properly.

4.3 Inflate the plugs to manufacturer's recommended pressure.

4.4 Determine the test time for the section to be tested using Table I or XI from ASTM C 828-80.

4.5 Add air from the air testing unit into the sewer line via the air valve stem on the inflatable plugs. Raise the pressure in the line to 4 psi. After this pressure is attained, allow the pressure to stabilize at or above 3.5 psi. (If this pressure cannot be attained, record in field book, stop the test.)

4.6 Using a stop watch, measure the time required for the pressure to drop 1 psi from the starting pressure. Record this time in field book.

4.7 Depressurize the line and repeat the test two more times.

4.8 Decontaminate all personnel and equipment that entered manholes over the manhole as they exit by the direct application of pressurized steam from the MKE steam cleaning unit. (See MKE Health and Safety Plan.)

4.9 Proceed to the next site or to final decontamination of all personnel and equipment at Building 316A.

5.0 RECORDS

5.1 Data will be recorded in a field book. Records generated will be maintained in accordance with the SOP for records control.

5.2 A "Daily Report of Field Activities" form will be completed and signed by an MKE and subcontractor representative.

6.0 ATTACHMENTS

ASTM C 828-80
"Daily Report of Field Activities" form

AMERICAN NATIONAL STANDARD

ASTM C 828 – 80

AMERICAN SOCIETY FOR TESTING AND MATERIALS
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If not listed in the current combined index, will appear in the next edition.

Standard Practice for LOW-PRESSURE AIR TEST OF VITRIFIED CLAY PIPE LINES[1]

This standard is issued under the fixed designation C 828; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This practice defines procedures for testing vitrified clay pipe lines, using low-pressure air, to demonstrate the structural integrity of the installed line.

1.2 This practice for testing shall be performed on lines after connection laterals, if any, have been plugged and braced adequately to withstand the test pressure, and after the trenches have been backfilled for a sufficient time to generate a significant portion of the ultimate trench load on the pipe line. The time between completion of the backfill operation and low-pressure air testing shall be determined by the approving authority.

1.3 This practice may also be used as a preliminary test, which enables the installer to demonstrate the condition of the line prior to backfill and further construction activities.

1.4 This practice is suitable for testing gravity-flow sewer pipe constructed of vitrified clay or combinations of clay and other pipe materials.

NOTE 1—The values stated in inch-pound units are to be regarded as the standard.

2. Applicable Document

2.1 *ASTM Standard*:

C 12 Recommended Practice for Installing Vitrified Clay Pipe Lines[2]

3. Summary of Practice

3.1 The section of the line to be tested is plugged. Air, at low pressure, is introduced into the plugged line. The line passes the test if the rate of air loss, as measured by pressure drop, does not exceed a specified amount in a specified time. This may be determined by the use of Table 1, or calculated by use of the formulas in Appendix X1.

4. Safety Precautions

4.1 The low-pressure air test may be dangerous to personnel if, through lack of understanding or carelessness, a line is overpressurized or plugs are installed improperly. It is extremely important that the various plugs be installed so as to prevent the sudden expulsion of a poorly installed or partially inflated plug. As an example of the hazard, a force of 250 lbf (1112 N) is exerted on an 8-in. (200-mm) plug by an internal pressure of 5 psi (34 kPa). Observe the following safety precautions:

4.1.1 No one shall be allowed in the manholes during testing because of the hazards.

4.1.2 Install all plugs securely.

4.1.3 When lines are to be tested, it may be necessary that the plugs be braced as an added safety fator.

4.1.4 Do not overpressurize the lines.

5. Preparation of the Line

5.1 Air may pass through the walls of dry pipe. This can be overcome by wetting the pipe. Usually, moisture absorbed from the backfill is sufficient to cope with this situation. If the

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[1] This practice is under the jurisdiction of ASTM Committee C-4 on Vitrified Clay Pipe and is the direct responsibility of Subcommittee C04.20 on Methods of Test and Specifications.

Current edition approved March 19, 1980. Published June 1980. Originally published as C 828 – 75T. Last previous edition C 828 – 78.

[2] *Annual Book of ASTM Standards*, Part 16.

problem persists, segmental testing of the line will establish if there is a significant leak.

5.2 A wetted interior pipe surface is desirable and will produce more consistent test results. Where pratical, clean the line prior to testing to wet the pipe surface and eliminate debris.

6. Procedure

6.1 Determine the test time for the section of line to be tested using Table 1 or X1 or the formulas in Appendix X1.

6.2 Plug all openings in the test section.

6.3 Add air until the internal pressure of the line is raised to approximately 4.0 psi (28 kPa). After this pressure is reached, allow the pressure to stabilize. The pressure will normally drop as the air temperature stabilizes. This usually takes 2 to 5 min, depending on the pipe size. The pressure may be reduced to 3.5 psi (24 kPa) before starting the test.

6.4 When the pressure has stabilized and is at or above the starting test pressure of 3.5 psi (24 kPa), start the test. If the pressure drops more than 1.0 psi (7 kPa) during the test time, the line is presumed to have failed the test. If an 1.0-psi drop does not occur within the test time, the line has passed the test.

NOTE 2—Ground water above the pipe will reduce air loss. If the section of line under test shows significant infiltration, the agency may require an infiltration test. Refer to 11.2 of Recommended Practice C 12.

7. Test Time

7.1 Table 1 shows the required test time, T, in minutes/100 ft of pipe for each nominal pipe size. Test times are for an 1.0-psi (7-kPa) pressure drop from 3.5 to 2.5 psi (24 to 17 kPa). Table 1 has been established using the formulas contained in the appendix.

7.2 If the section of line to be tested includes more than one pipe size, calculate the test time for each size and add the test times to arrive at the total test time for the section.

7.3 It is not necessary to hold the test for the whole period when it is clearly evident that the rate of air loss is less than the allowable.

TABLE 1 Minimum Test Time for Various Pipe Sizes

Nominal Pipe Size, in.	T (time), min/100 ft	Nominal Pipe Size, in.	T (time), min/100 ft
3	0.2	21	3.0
4	0.3	24	3.6
6	0.7	27	4.2
8	1.2	30	4.8
10	1.5	33	5.4
12	1.8	36	6.0
15	2.1	39	6.6
18	2.4	42	7.3

APPENDIX

X1. FORMULAS AND ALLOWABLE AIR LOSS STANDARDS USED IN PRACTICE C 828

X1.1 Calculate the required test time at a given allowable air loss as follows:

$$T = K \times \frac{D^2 L}{Q}$$

X1.2 Calculate air loss with a timed pressure drop as follows:

$$Q = K \times \frac{D^2 L}{T}$$

X1.3 *Symbols:*

D = nominal size, in. (mm),
$K = 0.371 \times 10^{-3}$ for inch-pound units,
$K = 0.534 \times 10^{-6}$ for S.I. units,
L = length of line of one pipe size, ft (m),
Q = air loss, ft^3/min (m^3/min), and
T = time for pressure to drop 1.0 psi (7 kPa), min.

X1.4 An appropriate allowable air loss, Q, in cubic feet per minute, has been established for each nominal pipe size. Based on field experience, the Q's that have been selected will enable detection of any significant leak. Table X1 lists the Q established for each pipe size.

TABLE X1 Allowable Air Loss for Various Pipe Sizes

Nominal Pipe Size, in.	Q, ft³/min	Nominal Pipe Size, in.	Q, ft³/min
3	2	21	5.5
4	2	24	6
6	2	27	6.5
8	2	30	7
10	2.5	33	7.5
12	3	36	8
15	4	39	8.5
18	5	42	9

X2. APPLICATION OF PRACTICE C 828

X2.1 In order to demonstrate the technique of applying this practice, the example in X2.2 has been prepared. It utilizes various pipe sizes, lengths, and conditions that may be encountered in the field. The example has been designed to illustrate the use of Table 1 and the formulas.

X2.2 *Example*—An installation has been made that consists of line 1: 300 ft (91.4 m) of 15-in. (375-mm) vitrified clay pipe with no laterals, and line 2: a reach of 350 ft (106.8 m) of 8-in. (200-mm) of vitrified clay pipe to which are attached 120 ft (36.6 m) of 4 in. (100-mm) laterals of vitrified clay pipe.

X2.2.1 *Problem*—What are the appropriate test times to use in order to demonstrate the integrity of the installed lines?

X2.3 *Solutions*:

X2.3.1 What is the appropriate test time, T, for line 1?

X2.3.1.1 Use Table 1, find time, T = 2.1 min/100 ft (30.5 m), for 15-in. (375-mm) pipe.

$$T_{15} = 300 \times \frac{2.1}{100} = 6.3 \text{ min}$$

X2.3.2 What is appropriate time for line 2?

X2.3.2.1 *Solution*—Use Table 1.

$$T_8 = 350 \times \frac{1.2}{100} = 4.2 \text{ min}$$

$$T_4 = 120 \times \frac{0.3}{100} = 0.4 \text{ min}$$

Total test time 4.6 min

X2.3.3 If further analysis is desired, the following example is provided:

X2.3.3.1 If in the test of line 1, the 1.0-psi (7-kPa) pressure drop occurs in 3.3 min instead of 6.3 min. what is the rate of air loss?

$$Q = K \times \frac{D^2 L}{T}$$

where:

$$Q = 0.000371 \times \frac{15^2 \times 300}{3.3} = 7.6 \text{ ft}^3/\text{min}.$$

This exceeds the 4 ft³/min allowed in Table X1.

X2.3.3.2 What further courses of action might be considered in resolving this excess rate of air loss?

(*1*) Segmentally test the line and compare the time-air loss values in each segment.

(*2*) If the values in each segment are comparable. the air-loss problem may be distributed throughout the line, and further analysis should be made.

(*3*) If the values in each segment are significantly different, each segment may be evaluated and further analysis be made in order to determine the location of any significant air losses.

DAILY REPORT OF FIELD ACTIVITIES

Project: _____ Report Number: _____

Subcontractor: _____ Date: _____

Weather: _____

Safety: _____

Developments That Could Lead To A Change Order Or A Delay:

_____

_____

_____

Work Performed Today: _____

_____

_____

_____

_____

Personnel Employed: _____

_____

_____

Equipment Utilization (Type, Status, Time): _____

_____

_____

_____

_____

_____

Signatures:

MKE: _____

Subcontractor: _____

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to document the procedures to be followed in the jet cleaning and televising of selected sewers at RMA. The goal of televising the interior of the sewers is to provide information that will assist the investigators in refining the selection of specific sewer excavation sites. An additional benefit to be derived from this program is that of documenting through the use of the jet cleaning equipment the continuity and alignment of sewer lines that had previously been air tested.

2.0 REFERENCE

Standard Task Operating Procedures, MKE Health and Safety Plan

3.0 DEFINITIONS AND RESPONSIBILITIES

3.1 Subcontractor - Guildner Pipeline Maintenance, Inc.

3.2 Health and Safety Supervisor - John Schmerber

3.3 Task Manager - Alan Notary

3.4 Decontamination Support - MKE personnel, as needed

4.0 PROCEDURE

4.1 The following procedure is subsequent to the standard health and safety procedures to be followed during the approach, monitoring and entry of manholes at RMA.

4.2 Insert the high pressure (1500 psi) water jet hose into the downstream end of the section of sewer line to be cleaned. Cleaning the line in this direction will pull liquids and solids to the downstream line. In those areas where several sections of line in a series are to be televised, take care to execute the work from the downstream sections toward the upper reaches to prevent excessive solids from accumulating in the lower end of the system.

4.3 With the water jet running at full flow, run the hose from the entry manhole to the next manhole or as far as the hose will travel before hitting an obstruction. If an obstruction is reached, "hammer" on it by pulling out a short length of hose (one arm's length) and releasing the hose, allowing it to repeatedly ram the obstruction. If this technique clears the obstruction, jet to the next manhole.

4.4 Once the next manhole is reached, or if the obstruction cannot be cleared, engage the hose reel and slowly (one foot per second) winch in the jet hose while maintaining full water flow. Steam clean the hose continually as it exits the manhole.

4.5 Repeat this process (4.3-4.4) until the water flowing through the downstream manhole appears clean, or until any obstructions encountered prove not to be passible. (This will require the judgment of the Task Manager and the Subcontractor.) Where obstructions are found, mark the point on the jet hose with duct tape, remove the hose and measure the distance from the obstruction to the entry manhole. Record this length in the field book.

4.6 In sewer sections where the jet hose does not encounter any obstructions, once the cleaning process is complete, remove the jet hose, fasten the TV camera winch cable to the nozzle and string the cable between manholes. Remove the jet hose.

4.7 Enter the manhole and connect the cable to the skid-mounted TV camera. (Proper skid sizes shall be used to keep the camera aligned in the center of the pipe.) Before inserting the camera assembly into the sewer line, the camera man shall slowly pan the camera around the circumference of the manhole, pausing at any unusual or noteworthy areas. Insert the camera into the sewer pipe.

4.8 While maintaining communication between the winch operator and the Subcontractor representative in the TV truck via "walkie-talkies" or hand signals, the winch operator shall pull the TV unit through the line at a slow, steady rate. At locations of interest determined by the Task Manager or his representative, the winch operator may be

instructed to pause for extended viewing. In some instances, the TV camera may be pulled backwards and then restarted to review a particular length of pipe.

4.9 The video recorder unit in the TV truck shall be operated on the fastest tape speed available (two hours for a T-120 video tape). A log will be completed in the TV truck by the Subcontractor while observing the interior of the sewer on the TV monitor.

4.10 Once the camera travels the full length of the section under investigation, or reaches an obstruction that cannot be passed, the camera will be pulled backwards while continually steam cleaning the camera power supply cable as it exits the manhole. Disconnect the camera assembly from the winch cable and remove the camera unit, pulleys and any other equipment from the manhole. Steam clean all equipment that exits the manhole over the manhole.

4.11 Relocate the steam cleaner at the second manhole and slowly reel in the winch cable from the sewer, steam cleaning continuously.

4.12 Proceed to the next investigation site or final decontamination of all personnel and equipment at Building 316A.

5.0 RECORDS

5.1 All data (such as locations of obstructions, etc.) shall be recorded in a field book in accordance with the SOP for records control.

5.2 The TV log prepared by the Subcontractor will be turned into the MKE Task Manager along with the video tape of the day's activities. These will be transported daily to the MKE Denver office for storage in the DCS vault.

5.3 A "Daily Report of Field Activities" form will be completed and signed by an MKE and Subcontractor representative.

6.0 ATTACHMENTS

Subcontractor TV log
"Daily Report of Field Activities" form

APPENDIX C
DAILY SUMMARY OF SEWER INVESTIGATIONS

DATE	ACTIVITY
11-25-85	Started air testing W28 - W29
11-26-85	W28 - W29 did not hold pressure (i.e., failed)
12-02-85	Failed to insert plug in W21; couldn't air test W21 - W22
12-03-85	Air tested: W21-W17 (6") failed, 165' W17 - W18 (6") failed, but invalid due to service line to 316A W25 - W26 failed, 85' W26 - W27 couldn't insert plug in W27 - aborted
12-04-85	Air tested: M.H. A-B (Bldg. 732) failed, 50' 119B - 117B failed, 180' S9 - S5 failed, 160' S5 - S6 failed, 135' S6 - S13 failed, 125'
12-05-85	Jetted: ~195' of 200' line W28 to W29, line was blocked ~10' from W29
12-06-85	Jetted: W21 - W22, 100' W21 - W17, 165' W17 - W18, 180' W26 - W27, 215'
12-10-85	TV'ing not accomplished @ W17 - W18
12-11-85	TV'ing not accomplished @ W22 - W21
12-12-85	TV'd 99' from W22 - W21, 100'
12-13-85	Jetted W26 - W27, 215'
12-16-85	Jetted from 119B to 117B, 180'
12-17-85	TV'd ~90% of 117B to 119B, 161'
12-18-85	TV'd <20', camera failed under 7th Ave.
12-19-85	TV'd under 7th (125'), jetted from 7th Ave. North 300'

DATE	ACTIVITY
12-24-85	Jetted W21 to W17, 165' Tried to jet W23 - W24, blocked @ E. end of 525 (90') Tried to jet S5 - S9, blocked ~15' from S5 Jetted S6 - S5 - S3, 340'
12-31-85	TV'd S6 - S5 - S4 - S3, 340'
01-02-86	TV'd from W21 to W17, blocked 32' from W21
01-03-86	Jetted & TV'd M.H. 40 to M.H. 42 (Section 26), 490'